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179

PRINCIPLES
OF
ELECTRICITY,

CONTAINING

Divers new Theorems and Experiments,

TOGETHER WITH

An ANALYSIS

Of the ſuperior Advantages of high and pointed Conductors.

This TREATISE comprehends an Explanation of an *electrical* RETURNING STROKE, by which, fatal Effects may be produced, even at a *vaſt Diſtance* from the Place where the Lightning falls.

By Charles Viſcount MAHON, F. R. S.

LONDON:
Printed for P. ELMSLY, in the STRAND.
M.DCC.LXX.IX.

ADVERTISEMENT.

THE Author, having judged it proper, for the ſake of greater perſpicuity, to add an APPENDIX to the following Treatiſe, wiſhes that, that APPENDIX may be conſulted, for the Illuſtration of ſuch Propoſitions, as are contained in the SECTIONS that he has referred to, therein; a Liſt of which SECTIONS, in order to ſave unneceſſary trouble to the Reader, he has hereto annexed.

If any Perſon ſhould be inclined to read ſuch Parts only of this Work, as are almoſt entirely free from Mathematicks; he may, without inconvenience, ſkip, from SECTION 100 of PART III, to the End of PART VII; provided he admit the Truth of the Propoſitions there demonſtrated, as ſtated (ſhortly) in the following TABLE of CONTENTS.

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SECTIONS, of the TREATISE, referred to,	In the following SECTIONS, of the APPENDIX.
§ 7 and 8,	§ 573 to § 576.
§ 12, § 19 and § 20,	§ 577 to § 580.
§ 29,	§ 581 to § 583.
§ 53,	§ 584.
§ 60 and § 68,	§ 585.
§ 82,	§ 586.
§ 100, § 101 and § 102,	§ 587 to § 589.
§ 150 & *ſeq.*	§ 590.
Note to § 201,	§ 591.
§ 308,	§ 592 to § 602.
§ 347,	§ 603 to § 606.
§ 391,	§ 607 to § 611.
§ 423,	§ 612.
§ 425,	§ 613 to § 614.
§ 528,	§ 615 to § 617.
§ 531 & *ſeq.*	§ 618.
§ 543,	§ 619 to § 636.

TABLE OF CONTENTS.

PREFACE.

ADVERTISEMENT.

PART I.

§ 1 to § 4, Explanatory Introduction.

§ 5 to § 9, General Ideas on Electricity, and on electrical Atmoſpheres ſurrounding charged Bodies.

Note to § 10, Electrometers compared: Figures 1 and 2.

§ 10 to § 18, Experiment [1, 2, 3 and 4] with an exhauſting Air-Pump, in which, an Electrometer was incloſed: Figures 3 and 4.

§ 19 to § 21, Important Concluſions drawn, with reſpect to *electrical Atmoſpheres.*

§ 22 to § 27, All electrical Attractions and Repulſions, reduced to *one* plain Principle.

§ 28 to § 29, Nature of a *ſtriking-Diſtance,* explained.

§ 30 to § 49, Explanation, of the Reaſons why *prominent* metallick *Points* tend gradually to *unelectrify* the charged Bodies (whether *poſitive* or *negative*), with which they are connected; and of the Reaſon why *round* metallick Bodies do *not*: Figures 5, 6, 7 and 8.

§ 50 to § 54, Mr. *Archard's* intereſting Experiments, relative to metallick Points.

§ 55 to § 74, Explanation of the general Rule, that, an inſulated conducting Body, immerged in an electrical Atmoſphere (whether *negative* or *poſitive*), will become, at the *ſame* time, *poſitively* electrified, *negatively* electrified, and *not electrified at all*: Figure 9.

PART II.

§ 75 —— *Repetitions* propoſed to be ſaved, by conſidering the charged Body as being always electrified *in plus.*

§ 76 to §.84, Experiments [5, 6, 7, 8 and 9] related, to prove, by means of a *ſingle Electrometer*, the general Propoſition ſtated at the End of PART I: Figure 9.

§ 85 to § 94, Experiments [10, 11 and 12] related, to prove the ſaid general Propoſition, by means of a *pair of Electrometers*: Figure 9.

Note to § 87, Precautions neceſſary to be taken, in order, for theſe laſt Experiments to ſucceed properly.

PART III.

§ 95 to § 107, Experiments [13 and 14] related, to prove, that an *inſulated* conducting Body (free from Points, &c.) which is immerged in an electrical Atmoſphere, becomes *electrified*, only by having the electrical Fluid, *contained within itſelf*, *diſturbed*: Figure 9.—*Ratio* between the Quantity of Electricity *ſuperinduced* upon an inſulated trebly-electrified Body, and the *plus* or *minus* Electricity therein *contained*, determined.—The *Force* or *Power* of ſuch *plus*, or *minus*, Electricity, aſcertained.—And the *coincidence* of the *neutral* or *unelectrified* Point, with the Plane that would divide into *two equal* Portions the whole Quantity of *ſuperinduced* Electricity, proved.

Note to § 101, *Definition* given, of the Quantity of Electricity *ſuperinduced* upon a Body, and of the *Denſity of the Electricity* of any electrified Body or electrical Atmoſphere.

PART IV.

§ 108 to § 109, Rule, for determining the *neutral* Point; the poſition of which will depend, upon the *Form* of the trebly-electrified Body, and upon the *Law* according to which the *Denſity of the Electricity* of electrical Atmoſpheres does decreaſe.

§110 to §115, If the *Form* of the trebly-electrified Body be *cylindrical*; and if the *electrical Denſity* of electrical Atmoſpheres be in the *ſimple inverſe Ratio of the Diſtance*; then, the *neutral* Point will be found by dividing an *hyperbolical Area* into *two equal* Parts, which may be done, by taking a *geometrical mean-proportional*, between two Ordinates, or between two Abſciſſes: Figures 9 and 10.

§116 to §128, Demonſtration given, of theſe Propoſitions.—The *abſolute Size* of the Hyperbola, to be made uſe of, is immaterial: Figures 9 and 10.

PART V.

§129 to §135, If the *electrical Denſity* of electrical Atmoſpheres be *inverſely as the ſquare of the Diſtance*; then, the *neutral* Point will be found, by dividing a *finite hyperbolick Solid* into *two equal* Solids, which may be done, by taking an *arithmetical mean proportional* between two Ordinates, or by taking an *harmonical mean proportional* between two Abſciſſes: Figures 9 and 11.

§136 to §146, Theſe Propoſitions demonſtrated, by means of *Torricelli's* infinite acute hyperbolick Solid, &c: Figures 9 and 11.

§147 to §148, The *ultimate* Poſition, and the *evaneſcent* Poſition, of the *neutral* Point, determined: Figure 9.

PART VI.

§149 to §171, Experiment [15] related, to ſhew, that the *neutral* Point, in an inſulated conducting Body of a certain Form, is a *fourth* Point of an *harmonical* Diviſion: Figure 9.

§ 168 —— TABLE, of the different *Diſtances*, at which, that Experiment [15] was made, and of the reſpective *Reſults*: Figure 9.

§172 to §174, Propoſitions relative to an *upright Cylinder*, and the (*Sphere* or) *ſemi-ſphere* inſcribed therein: Figures 9 and 12.

§175 to §178, From theſe *Propoſitions*, from the *Theory of an harmonical Diviſion*, and from the electrical *Experiments* laſt-mentioned; the

the *Denſity of the Electricity* of electrical Atmoſpheres is proved, in fact, to be *in the inverſe Ratio of the ſquare of the Diſtance*: Figure 9.

PART VII.

§179 to §181, Neceſſity of performing the laſt ſet of Experiments, with particular Attention —Alſo,

Conſequence of a ſmall inſulated conducting Body being brought into contact with the *near* End of the trebly-electrified Body; and conſequence of its being brought into contact with the *remote* End: Figure 9.

§182 to §183, Conſequence of the trebly electrified Body being made to communicate with the *Earth*; and conſequence of its being ſupported upon *imperfect Conductors*: Figure 9.

§184 to §186, Conſequence of the trebly-electrified Body being ſurrounded by *damp Air:* Figure 9.

§187 to §188, Conſequence of *Points* being placed within the *electrical Atmoſphere* of the trebly-electrified Body: Figure 9.

§189 to §192, Conſequence of *Points* being placed upon the *near* End of the trebly-electrified Body itſelf; and conſequence of their being placed upon the *remote* End: Figure 9.

§193 to §194, Conſequence of the trebly-electrified Body being placed *too near* to the charged Body producing the electrical Atmoſphere ſuperinduced: Figure 9.

§195 to §196, Account of what is abſolutely neceſſary, in order, for the Experiments upon the *neutral* Point to ſucceed properly: Figure 9.

§197 to §198, The Experiments upon the *neutral* Point repeated, with metallick Bodies of different Sizes, &c; and alſo, with a *negative* (inſtead of a *poſitive*) Apparatus: Figure 9.

§199 to §201, The *Law*, according to which, the *Denſity of the Electricity* of electrical Atmoſpheres, decreaſes, is the ſame as *that* according to which, *Heat*, *Light*, and the *univerſal Force of Gravity*, decreaſe. And the Author was inſenſibly led, to the concluſive

concluſive *Demonſtration* he has given of the above-mentioned *Law* in Electricity, by Mr. *Le Sage's* ingenious *Syſtem of Gravitation.*

Note to §201, A ſimilar Propoſition to that (explained above) of an *harmonical Diviſion,* extends alſo, in certain Caſes, to the *Center of Gravity* of Bodies of particular Forms: ſee alſo § 591.

PART VIII.

§202 to §211, The electrical *returning Stroke* explained. And Experiments [16, 17, 18 and 19] made with the Bodies AB and EF: Figure 13.

§212 to §215, Experiment [20] made with the Bodies G and H: Figure 13.

§216 to §225, Experiments [21, 22 and 23] made with the Bodies IK and MNN: Figure 13.

§226 to §234, Experiments [24, 25 and 26] made with the Bodies QQO and RR: Figure 13.

§235 to §243, Experiment [27] made with the Bodies SST and VXX: Figure 13.

§244 to §247, Experiment [28] made with the Bodies YY and ZZ: Figure 13.

PART IX.

§248 to §276, Further inveſtigation of the curious Effects of the *returning Stroke.* Experiments [29, 30, 31, 32, 33, 34, 35, 36 and 37] made with the Apparatus repreſented in Figure 14; and an Explanation given, of the *Reaſon* of each ſeparate Effect.

PART X.

§277 to §310, Intereſting Experiments [38, 39, 40, 41, 42 and 43] made with the Apparatus repreſented in Figure 15.—The extreme pungency, in ſome caſes, of the *returning Stroke,* compared to a *Leyden Shock.*—Methods of increaſing the *Force* of the *returning Stroke,* explained.—And the Effects, which the Author aſcribes to the *returning Stroke,* are proved *not* to proceed from the *main Stroke* itſelf being any-wiſe *divided* at the time of the Exploſion.

PART XI.

PART XI.

§311 to §316, The above-mentioned Experiments applied to *natural Electricity*.—A *returning Stroke* may produce fatal Effects, at a Place, which is even at a *prodigious* Diſtance from the *Place where the* Lightning falls.—And it may happen, that Perſons, ſituated in an *intermediate* Place, would receive no Detriment whatever: Figure 16.

§317 to §322, Reaſons given, why the Effects which have been produced in natural Electricity, by the *returning Stroke*, could *not* hitherto have been aſcribed to the *proper Cauſe*.

§323 to §332, Effects, which may be accounted for, by means of the eleccal *returning Stroke*: *viz.*—Many Perſons, far aſunder, being all *knocked down at once*, in a Thunder-Storm.—Perſons having their *Feet*, and *no other* Part of their Body, apparently damaged by Lightning.—Animals being killed by Lightning, without the Lightning falling *near* them.—A Perſon having received an *electrical Shock* from an interrupted metallick conducting Rod, at the inſtant of a *diſtant Exploſion* from a Thunder-Cloud.—A ſtrong, bright and ſudden *Stroke* of electrical Fire, having taken place, in the interruption of a conducting Rod, which was however *not ſtruck* by Lightning.

§333 to §334, *Particular Parts* of a Building may be conſiderably damaged, by an electrical *returning Stroke* even in the caſe of the Roof being entirely covered with Lead properly connected with the Earth.

§335 to §336, Perſons, inhabiting ſuch a Building, are *not in perfect Security*, during a Thunder-Storm.—And Perſons, who are even *inſulated* in the middle of a large Room, may, under certain circumſtances, be in danger from the *returning Stroke*.

§337 to §347, Reaſons given, why the *ſtrength* of the electrical *returning Stroke* will *not* [under *given* circumſtances] be any-wiſe decreaſed by its being produced by a very *remote* Exploſion.—Alſo, why the *returning Stroke* may be *ſufficiently powerful*, to produce very fatal Effects, upon Perſons, Animals, and particular Parts of Buildings.

PART XII.

PART XII.

§348 to §361, *Manner*, in which, Conductors, of *different* Terminations, act upon any *ſuperinduced* electrical Atmoſphere, explained. Vulgar *Error*, that *metallick Points* ATTRACT the Matter of Lightning, refuted.—*Two caſes* diſtinguiſhed; *viz.* the Attraction of the *electrical Matter* from the Clouds; and the Attraction of the electrified *Cloud* itſelf.—*Firſt* of theſe caſes, examined.—Cauſe of the *apparent Attraction* of Points, explained. —Reaſons given, why a *pointed Conductor* tends *gradually* to *diſcharge* the Electricity, of any electrical Atmoſphere [whether *poſitive* or *negative*] in which it is immerged.

§362 to §372, A *pointed metallick Conductor* conſidered ſimply as an HOLLOW PIPE, which is *open* at its UPPER END, as well as at its *lower* Extremity.—And the abſurdity ſhewn, of ſuppoſing, that *metal Points* do, in reality, *invite, ſolicit and attract the Matter of Lightning* from the Clouds.

§373 to §383, The great and eſſential *Difference* that there is, between Conductors with *Balls* or *rounded Ends*, and thoſe with *acute Points*, explained.—The *Security*, derived from a metallick Conductor, proved to be, in a very great degree, *deſtroyed*, by any *round* Body being placed upon its upper Extremity.

PART XIII.

§384 to §387, *Three* Ways ſpecified, in which Damage may be done by Lightning; *viz.* by the *main Stroke*, by the *lateral Exploſion*, and by the *returning Stroke.*—A *main Stroke* may be, either *direct*, or *tranſmitted.*

§388 to §391, MANNER, in which, an *high and acutely pointed Conductor* tends to prevent a *direct main Stroke of Exploſion*, explained.

§392 to §395, Reaſons given, why a Conductor, terminating in a *Ball* or *rounded End*, will *not* tend to produce the ſame ſalutary Effect.

PART XIV.

PART XIV.

§396 to §423, *Another Manner* explained, in which, an *high and pointed* Conductor tends to prevent a *direct main Stroke* of Exploſion.— And the great Difference, between the reſpective actions, of *Balls* and of *Points*, in this laſt-mentioned reſpect, explained: Figures 17 and 18.

PART XV.

§424 to §430, The *ſecond* of the two caſes mentioned in PART XII [*viz.* the Attraction of the Body of an electrified *Cloud* itſelf, towards different kinds of metallick Conductors,] examined.— The Attraction of Thunder-Clouds towards metal *Balls* or *rounded Ends*, proved.

§431 to §433, The Reaſon given, why Thunder-Clouds will *not* be attracted by *prominent acute metallick Points* properly connected with the Common-Stock.

§434 to §436, Another Reaſon given, why Thunder-Clouds will *not* be attracted by ſuch *metallick Points.*

§437 to §443, Cauſe, of electrified Bodies becoming *ſilently diſcharged* by the gradual approach of *metal Points,* explained.—And an intereſting Obſervation, made, at *Philadelphia*, by Dr. *Franklin*, related.

PART XVI.

§444 to §448, Tendency of *pointed Conductors* to prevent any *tranſmitted main Stroke of Exploſion*, propoſed to be proved.—*Two* caſes diſtinguiſhed; *viz.* Either, that the ſecundary Clouds will receive Electricity, with *facility*, or *not* with facility.—*Firſt* caſe reduced to what was ſaid above.—In the *ſecond*, two caſes diſtinguiſhed; *viz.* Either, that the ſecundary Clouds will be *pending* to the main Cloud; or, will be *floating* independent of it.

§449 to §457, Caſe of *pending* Cloud examined.—Dr. *Franklin's* Experiment with the Lock of Cotton, and Mr. *Wilcke's* important Obſervation, related.—Reaſons given, for laying great ſtreſs upon the laſt-mentioned Experiment.

§458 to §467, Experiments of mine [44, 45 and 46] related, to prove one Superiority of *high and pointed* Conductors: Figures 19 and 20.

§468 to §476, Another Set of Experiments of mine [47, 48 and 49] related, to prove another Superiority of *high and pointed Conductors*: Figures 21, 22 and 23.

PART XVII.

§477 to §478, Caſe, of ſecundary Clouds *floating* independent of the main Cloud, propoſed to be examined.—*Three* caſes diſtinguiſhed; *viz.* that the *floating* Cloud will be, either electrified with the *contrary* Electricity to the main Cloud, electrified with the *ſame* Electricity as the main Cloud, or *not electrified at all.*

§479 to §482, The *firſt* of theſe caſes, examined.

§483 to §485, The *ſecond* of theſe caſes, examined.

§486 to §493, The *third* of theſe caſes, examined.—And Concluſion drawn.

PART XVIII.

§494 to §496, *High and pointed Conductors* tend powerfully to prevent the *lateral Exploſion.*

§497 to §500, High and pointed Conductors tend likewiſe [in *two* different ways] powerfully to prevent the electrical *returning Stroke.*

§501 to §517, Experiments [50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60 and 61] related, to ſhew the reſpective Tendencies of *Points*, to *prevent* [and of *Balls*, *not* to prevent] the *returning Stroke*: Figure 15.

Note to §514, A fact, obſerved by the late Mr. *Henly* F. R. S. explained.

§ 518 —— General Concluſion.

PART XIX.

§519 to §544, The *neceſſary Requiſites* for erecting Conductors, [which Requiſites are ſhewn to be *eleven* in number,] ſeperately explained.

PART XX.

§545 to §571, Demonſtration given, of the ſurprizing and important Propoſition, that, *high and pointed* metallick Conductors [properly erected] tend, in the moſt *powerful* manner, to *ſecure* Perſons and Buildings againſt Lightning, in the Caſe, when there is the *greateſt Quantity of electrical Fire* in the Clouds.

APPENDIX.

APPENDIX.

§572 to §580, The nature of *electrical Atmoſpheres* more fully explained.
§581 to §583, Experiment [62] tending to illuſtrate the nature of a *ſtriking Diſtance*, related.
§584 to §586, Obſervation on Mr. *Archard's* nine Points.—Further Explanation of the reaſon why a *trebly-electrified* Body does neither acquire, nor loſe, Electricity.—And a remark on Figure 9.
§587 to §589, Some Propoſitions elucidated from the known Principle, that the *plus* (or *minus*) Electricity *contained* in a conducting Body, reſides *entirely on its external Surface.*
§590 to §591, Electrometer uſed in my fifteenth Experiment, mentioned.—And a Propoſition relating to the *Center of Gravity*, explained.
§592 to §602, Experiments [63, 64, and 65] related, to prove the *pungency* of the electrical *returning Stroke* produced even by a ſmall Quantity of Electricity, and to ſhew from whence proceeds the *ſenſation of the Leyden Shock.*
§603 to §606, Experiment [66] related, to ſhew that *Metal may be melted, by means of the returning Stroke,* without the aſſiſtance of any *coated* non-conducting Subſtance whatſoever.
§607 to §611, Experiment [67] related, to confirm the Principles that are ſtated in PART XIII.
§612 ——— Caſe of the Clouds being *negative*, conſidered.
§613 to §614, A curious Experiment related by *Æpinus*, explained.
§615 to §617, Experiment [68] related, to prove that the electrical properties of a metallick *Point* do *not* depend upon its *Form.*
§618 ——— Experiments, of Dr. *Franklin*, and of Mr. *Nairne*, F. R. S, referred to.
§619 to §636, The beſt method of erecting Conductors for making *Experiments*, Explained; and Experiments [69, 70 and 71] related, to prove the advantage of the method here propoſed.

PREFACE.

SHOULD the Reader have heard any Thing, concerning the Diſputes that have ariſen in England upon the Subject of Conductors for Lightning, he may perhaps be aſtoniſhed *not* to find, in the following Pages, any notice taken of the late electrical Experiments of Mr. *Benjamin Wilſon.* But the Author, who intends very ſoon to give to the World a *direct* Refutation of the Concluſions drawn from thoſe Experiments, thinks it improper, to confound an Explanation of new and important *Facts*, with a Refutation of Doctrines, which, had it not been for the various Doubts they have occaſioned in the Minds of ſome Men, would, in the Author's Opinion, not have deſerved much conſideration.

The Reader being ſuppoſed to be ſomewhat acquainted with the *common* Experiments, and *general* Properties, of Electricity; the Author has omitted many tedious and *elementary* Explanations. The Experiments and Obſervations, that he has lately made upon *Leyden* Jars, &c. will be the ſubject of ſome future Publication.

PRINCIPLES

OF

ELECTRICITY.

PART I.

SECTION I.

NOTHING being ſo neceſſary, to the advancement of any Branch of Science, as the Inveſtigation of the Principles upon which it is founded; I ſhall endeavour, in the following pages, to eſtabliſh the *fundamental Laws of Electricity*; by means of which, I ſhall have it in my power to demonſtrate, that the influence of the electrical Fluid, is much more *extenſive*, than it has hitherto been imagined.

§ 2.

§ 2. In laying down, what I conceive to be the *true Principles* of Electricity, I ſhall take notice of a few of its Properties, with which the World is already acquainted; in order, to ſhew how naturally they lead, to the important *Facts* hereafter related. The exiſtence of thoſe Facts I diſcovered from the *Theory*, long before I attempted to prove that exiſtence, by means of Experiments; which, however, I have ſince done with the moſt invariable ſucceſs.

§ 3. I ſhall relate many Experiments, concerning a particular kind of electrical Shock, which I ſhall diſtinguiſh by the appellation of a *returning Stroke*; and I ſhall give a full explanation of the manner, in which *Perſons* may be deſtroyed, and *particular Parts* of Buildings be greatly damaged, by a Stroke of this kind; which *Stroke*, I ſhall prove *may* be produced by an electrical Exploſion, that takes place, even at *a vaſt Diſtance* from ſuch Perſons or Buildings.

§ 4. I ſhall alſo ſay a few things, concerning the action of *elevated and acutely-pointed* Conductors; and I ſhall ſhew in what manner, that ſimple and moſt excellent Invention tends to *ſecure* both Perſons and Buildings, againſt all accidents whatever which could reſult from natural Electricity; even againſt thoſe, which might proceed from the *above-mentioned* (hitherto unknown) *Cauſe*.

§ 5. It is well known, that all Bodies in nature, contain, at all times, a certain Quantity of the *electrical Fluid*; and as much of that Fluid as is contained in a Body, which is in its *unelectrified* (i. e. *natural)* ſtate, is called that Body's *natural ſhare* of Electricity. If, by any means, a Body be made to loſe any part of its *natural* ſhare of electrical Fluid; that Body is ſaid to become *minus* or *negative.* If, on the contrary, a Body be made, by any means, to acquire more *Electricity* than it ought naturally to contain; that Body is ſaid to become *plus* or *poſitive.*

§ 6. Whilſt the *electrical Equilibrium* between the Earth and the Clouds (or any other Bodies) is *not* diſturbed, the electrical Fire remains perfectly innocent; tho' all thoſe Bodies do contain, at all times, a conſiderable portion of that ſubtile and active Fluid. But, when any Cauſe ſhall happen to diſturb that *natural Equilibrium*, by rendering a body either *poſitive* or *negative*, it muſt neceſſarily produce the following conſequences.

§ 7. If the Body be *poſitive*, and if it be ſurrounded by *Air*; that electrified Body will depoſit, upon all the Particles of that Air which ſhall come ſucceſſively into contact with it, a proportional Part of its *ſuperabundant* Electricity. By which means, the *Air* ſurrounding that Body will alſo become *poſitively* electrified: that is to ſay, it will form around that *poſitive* Body, an electrical *Atmoſphere*, which will likewiſe be *poſitive.*

§ 8.

§ 8. If, on the contrary, the Body be *negative*; each Particle of Air that ſhall come into contact with it, will depoſit thereon a certain Part of its *natural* ſhare of Electricity. By which means, the circumambient *Air* will become *negative:* that is to ſay, it will form a *negative Atmoſphere*, around the Body which is *negatively* electrified.

§ 9. Some Electricians may be inclined to imagine, that the electrical Atmoſphere of a *poſitive* Body is *negative*; becauſe it produces ſometimes *negative* Effects: and that the electrical Atmoſphere of a *negative* Body *is poſitive*; becauſe it ſometimes produces *poſitive* Effects. But, thoſe Effects are eaſily to be accounted for, without adopting an unnatural and erroneous hypotheſis in order to explain them.

EXPERIMENT I.

Fig. 3. § 10. I took a pair of Cork-Ball Electrometers A B, whoſe Balls were three eighths of an inch in diameter, and whoſe *parallel legs*[†] were eight inches long; and I ſuſpended them to a hook, that was fixed to the under ſide of the braſs cap CD, of the glaſs Receiver EFGH, of an Air-Pump. The two legs of this Electrometer, in order to prevent their twiſting, were made of fine ſtraws, which had been previouſly well ſoaked in ſalt and water to make them conduct better. Each of theſe legs was ſuſpended at top, by a very fine linen thread of about *one twelfth* of an inch in length.

[†] I always make my Electrometers, ſo that, the legs ſhall hang *parallel* (as repreſented in Figure firſt), when the inſtrument is not electrified; inſtead of *meeting at top* as in the common way (repreſented in Figure ſecond): the electrometrical Balls may thereby be made to divaricate, with a much *ſmaller* Degree of Electricity, than would otherwiſe be the caſe. Becauſe, when the legs hang *parallel*; then, not only the *verſed ſine* of the angle of declination is

§ 11. In order, to render the glaſs Receiver a good *non-conductor* of Electricity, I cauſed it to be perfectly well dried by means of Fire. It was proper, in this Experiment, to avoid giving any friction to the glaſs Receiver, for fear of charging the glaſs.

§ 12. Upon charging a ſmall Prime-Conductor, which was made to communicate with the braſs cap of the glaſs Receiver, the electrometrical Balls divaricated above *two inches and a half* (Figure 4).

EXPERI-

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is equal to *nought*, when the angle of divarication is evaneſcent; but, the *verſed ſine* of the angle of declination, will, in every caſe, be *leſs* than when the legs of the Electrometer do *not* hang parallel. That is to ſay, that the *weight* neceſſary to be raiſed (in order to enable the electrometrical Balls to diverge, to a given Degree), will always be *leſs* when each leg hangs *perpendicular*, than when the legs hang with their upper Extremities *in contact*. This difference is particularly ſenſible, in *ſmall angles* of electrical divarication.

There is another improvement which I have made, in ſuch Electrometers as are intended for *extremely delicate* Experiments, which is, to ſuſpend the electrometrical Cork-Balls (which ought not much to exceed *one ſixteenth* of an inch in diameter), by threads of *fine flax* ſubdivided to the greateſt poſſible degree.

EXPERIMENT 2.

§ 13. I then began to *exhauſt* the Receiver; upon doing which, the Balls ſoon began to divaricate gradually *leſs and leſs*. And as ſoon, as the ſhort Barometer-Gage was got down to about *one quarter* of an inch (the Barometer being, that day, at the height of *twenty-nine inches and a quarter)*; the divarication of the Balls from each other, became reduced to *leſs* than *one quarter* of an inch.

§ 14. So that, by $\frac{116}{117}$ Parts, of the natural quantity of Air contained in the Receiver, being *exhauſted*; the divarication of the electrometrical Balls was diminiſhed to leſs than *one tenth* Part. For, the *chord* of the angle of divarication was decreaſed (as was ſaid before, § 12 and § 13), from above *two inches and a half*, to leſs than *one quarter* of an inch. That is to ſay, that the *verſed ſine* of the angle of divarication, was decreaſed conſiderably more than an *hundred times*; becauſe, *the verſed ſines are always as the ſquares of the chords.*

§ 15. I ſhould be inclined to imagine, if this Experiment were made with great accuracy, and with a proper Electrometer; that the *verſed ſine* of the angle of divarication, would always be in the *ſame Ratio*, as the *Denſity* of the Air in the Receiver: provided, that proper means were taken, to keep the apparatus ſufficiently free from moiſture during the Experiment.

EXPERIMENT 3.

§ 16. I then electrified the glaſs of the Receiver itſelf: but, as long as the Receiver remained *exhauſted* to the degree above-mentioned (§ 13), it was out of my power to cauſe the electrometrical Balls to divaricate above *one quarter* of an inch.

EXPERIMENT 4.

§ 17. I then let the Air return into the Receiver; which circumſtance alone, cauſed the Balls again to divaricate conſiderably, altho' I gave to the apparatus *no freſh ſupply of Electricity*. But, the Balls took up a ſhort time in coming to their full degree of divarication. The reaſon of which evidently was, that the *unelectrified* Air, which entered into the Receiver, could not receive *immediately*, from the charged apparatus, that degree of Electricity which it was able finally to acquire.

§ 18. I repeated theſe Experiments with the exhauſting Air-Pump, ſeveral times; and I always found reſults that were ſimilar.

§ 19. From theſe Experiments, it appears, that, when Bodies are charged with Electricity, it is the *Particles of (circumambient) Air being electrified*, that conſtitutes the *electrical Atmoſphere* which exiſts around thoſe Bodies.

§ 20. Now, ſince an *electrical Atmoſphere* (whether *negative* or *poſitive)* conſiſts of electrified *Air*; it evidently follows, that the *Denſity* of the Electricity of that Air, muſt be in ſome *inverſe Ratio of the Diſtance* from the charged Body, which cauſes that electrical Atmoſphere.

§ 21. That electrical Atmoſpheres do decreaſe *in denſity*, the more the Diſtance from the electrified Body is increaſed, is demonſtrable by means of a proper Electrometer, in every inſtance.

§ 22. From theſe ſimple conſiderations, it is eaſy to reduce, all the different *Phenomina* of electrical *attraction* and *repulſion*, to *one* plain and convenient Principle, derived from the very nature of a *diſturbed electrical Equilibrium*; namely, to the elaſtick tendency of the electrical Fluid, to impel every Body, charged either *in plus* or *in minus*, towards *that Part* of its electrical Atmoſphere, where its *natural electrical Equilibrium* would be the moſt eaſily reſtored.

§ 23. From this ſimple Principle, it is evident, that Bodies, which are charged with *contrary* Electricities, muſt tend to *approach* each other, whenever the ſkirts of their (*oppoſitely* electrified) *Atmoſpheres* interfere.

§ 24. From the ſame ſimple Principle, it is alſo eaſy to underſtand, why Bodies, that are charged with the *ſame kind* of Electricity, tend to *diverge* from each other.

Every Body that is electrified (whether *in plus* or *in minus*) has a conſtant tendency to return to its *natural ſtate*; and this cauſes it to electrify, in a certain degree, *other*

other Bodies in contact with it, and the *Air* in its vicinity, in a manner ſimilar to that explained above (§ 7 and § 8).

§ 25. If two Bodies (for example) be both *poſitive*; neither Body will be able to depoſit its *ſuperabundant* Electricity upon the other Body, which is alſo ſimilarly electrified *in plus*. It is therefore evident, from the ſimple Principle mentioned above (§ 22), that, if theſe Bodies be brought near each other, *each Body* will be impelled, towards the Particles of Air on its *other* ſide, which are electrified *in plus* only in a *ſmall* degree. That is to ſay, that each Body will tend to *diverge* from the other.

§ 26. If the Bodies, on the contrary, be both *negative*; neither Body will be able to have its *deficient* Electricity ſupplied from the other Body, which is alſo ſimilarly electrified *in minus*. It is therefore evident, from the ſimple Principle mentioned above (§22), that, if theſe Bodies be brought near each other, *each Body* will be impelled, towards the Particles of Air on its *other* ſide, which are electrified *in minus* only in a *ſmall* degree. That is to ſay, that each Body will tend to *diverge* from the other.

§ 27. So that, Bodies, which are charged with the *ſame kind* of Electricity (whether *poſitive* or *negative*), muſt neceſſarily tend to *diverge* from each other.

§ 28. From the above-mentioned conſiderations, that all electrical *Atmoſpheres* conſiſt of electrified Air; and that the *electrical Denſity* of all ſuch Atmoſpheres increaſes, when the Diſtance from the charged Body is decreaſed; it is eaſy to underſtand, what the nature of a *ſtriking-Diſtance*, is;

§ 29.

§ 29. For, a Body which is electrified, becomes capable of diſcharging its Electricity with an *Exploſion*, upon a conducting Body, of any given termination, placed within its *electrical Atmoſphere*, at any *given Diſtance* from it; when the *Denſity of the Electricity*, contained in that electrical Atmoſphere, *is ſufficient* to render that electrical Atmoſphere, *a ſudden Conductor* of Electricity to that *given Diſtance* from the charged Body.

Becauſe, the *Air* (like any other *non-conductor*) will, by being very powerfully electrified either *in plus* or *in minus*, become (on the *external Surface* of the Particles that compoſe it) a *Conductor* of an electrical Charge.

§ 30. From the above-mentioned conſiderations, that all electrical *Atmoſpheres* conſiſt of electrified Air; and that the electrical *Denſity* of all ſuch Atmoſpheres decreaſes, when the Diſtance from the charged Body is increaſed; it is moreover, eaſy to underſtand the reaſon, why metallick Bodies with *prominent metallick Points* will part with, or will receive, the electrical Fluid, *with a much greater degree of facility*, than metallick Bodies of any other ſhape whatever.

Fig. 5. § 31. We have ſeen above (§ 7), if any Body (ſuch as AB) be *poſitively* electrified, that the electrical *Atmoſphere* with which it is ſurrounded, will of neceſſity, be alſo *poſitive*.

§ 32. Therefore, if the *poſitive* Body AB, have *no prominent* Parts; if it be ſurrounded with *dry Air*; if it be perfectly well *inſulated*; and if it be ſo ſituated, as *not* to have, within the bounds of its ſenſible *electrical Atmoſphere*, any ſuch kind of conducting Body as would, in great meaſure, be able to *diſcharge* that Atmoſphere; the *poſitive* Body will *not* be able, without great difficulty, to *tranſmit* any conſiderable Portion of its *ſuperabundant* Electricity, to the maſs of Air GHKL, which ſurrounds the *denſe Part* CDEF of its electrical Amoſphere: becauſe, the *denſe Part* CDEF of the Atmoſphere of electrified Air (which *immediately* ſurrounds the *poſitive* Body AB, and which muſt therefore be the neceſſary *vehicle*, of whatever Part of the *ſuperabundant* Electricity of the inſulated Body AB, that Body AB might loſe), will, by being already very *poſitive*, *not* be able without great difficulty, to *receive* any additional Electricity.

§ 33. That is to ſay, that the *denſe Part* of the *poſitive Atmoſphere*, which always ſurrounds a *poſitive* Body, will neceſſarily cauſe a great *Reſiſtance* to the *Exit* of the electrical Fluid; whilſt that Body continues to be well inſulated.

§ 34. Now, let us ſuppoſe another metallick Body AB, exactly equal and ſimilar to the Body repreſented in Figure 5, but which has affixed to it, a piece of *tapering* wire MN, whoſe End N is very acutely *pointed*: and let us ſee what muſt be the neceſſary conſequence; ſuppoſing the Body AB to be well inſulated, and electrified *in plus*. Fig. 6.

§ 35. If this piece of *pointed* wire MN, be of ſuch a length, as to have its Extremity N, out of the *denſeſt Part* CDEF, of the *poſitive* Atmoſphere of the Body AB, which Atmoſphere does gradually decreaſe in denſity; then, the *Quantity* of *plus* Electricity contained in the wire, particulary at the Point N, being extremely ſmall (ſince, the *Surface* of that wire, particularly at the Point N, is very inconſiderable); it is evident, that the *denſe Part* of the *poſitive Atmoſphere of Air* round that wire, particularly round the Point N, will be likewiſe extremely ſmall (as is repreſented in Figure 6).

§ 36. Conſequently, the *Reſiſtance*, oppoſed by the *plus* Atmoſphere, at the Point N, to the *Exit* of Electricity from the Body AB, will alſo be extremely ſmall. Therefore, the *ſuperabundant* Electricity of the *plus* electrified Body AB (which conſtantly tends to quit that Body), will run out, in a much *greater Quantity* into the Air, through the Point N, where the *Reſiſtance* is very *ſmall*; than it will through any *non-prominent* Point whatever, of the Body AB, where the *Reſiſtance* is of neceſſity, *conſiderable*.

Fig. 7. § 37. If a *round* metallick Body PQ, be connected with a *poſitive* Body AB (which is equal and ſimilar to the Bodies repreſented in Figures 5 and 6); and if it be made to *project* into the Air, which ſurrounds that Body AB, in the ſame manner that the *pointed* metallick wire MN was made to project: it may be aſked what the reaſon is, that the *ſame Effect* does *not* take place, as in the other caſe?

§ 38. The reaſon is ſimply this. The greater the *Surface* of the prominent Body is; the more conſiderable will the *plus Atmoſphere* be, which ſurrounds that prominent *plus* Body PQ. From this it is evident, that the greater the *Surface* of the prominent Body is; the greater will the *Reſiſtance* be, which is oppoſed to the *Exit* of the *ſuperabundant* Electricity of the Body AB; and the ſmaller will the *Quantity* of electrical Fluid be, which can *gradually* run out, through the *prominent* Body, into the maſs of circumambient Air.

§ 39. Next, let us ſuppoſe, that the Body AB, be negatively (inſtead of *poſitively*) electrified; then, from what we have ſeen above (§ 8), the electrical Atmoſphere with which it is ſurrounded, will of neceſſity, be alſo *negative*. Fig. 5.

§ 40. Therefore, if the *negative* Body AB, have *no prominent* Parts; if it be ſurrounded with *dry Air*; if it be perfectly well *inſulated*; and if it be ſo ſituated, as *not* to have within the bounds of its ſenſible *electrical Atmoſphere*, any ſuch kind of conducting Body, as would, in great meaſure, be able to *diſcharge* that Atmoſphere; the *negative* Body will *not* be able without great difficulty, to have any conſiderable Portion of its *deficient* Electricity ſupplied, from the maſs of Air GHKL, which ſurrounds the *denſe Part* CDEF of its electrical Atmoſphere. Becauſe, the *denſe Part* CDEF of the *Atmoſphere of electrified Air* (which does immediately ſurround the *negative* Body AB, and which muſt therefore be the neceſſary *vehicle*, of whatever Part of the inſulated Body AB's *deficient* Electricity might be ſupplied), will, by being already very *negative*, *not* be able without great difficulty, to *part with* any further ſhare of Electricity.

§ 41. That is to ſay, that the *denſe Part* of the *negative Atmoſphere*, which always ſurrounds a *negative* Body, will neceſſarily cauſe a great *Reſiſtance* to the *Entrance* of the electrical Fluid; whilſt that Body continues to be well inſulated.

Fig. 6. § 42. Let us now ſuppoſe another metallick Body AB, exactly equal and ſimilar to the Body repreſented in Figure 5, but which has affixed to it, a piece of *tapering* wire MN, whoſe End N is very acutely *pointed*: and let us ſee what muſt be the neceſſary conſequence; ſuppoſing the Body AB to be well inſulated, and electrified *in minus*.

§ 43. If this piece of *pointed* wire MN, be of ſuch a length, as to have its Extremity N, out of the *denſeſt Part* CDEF, of the *negative* Atmoſphere of the Body AB, which Atmoſphere does gradually decreaſe in denſity: then, the *Quantity* of *minus* Electricity contained in that wire, particularly at the Point N, being extremely ſmall (ſince, the *ſurface* of that wire, particularly at the Point N, is very inconſiderable); it is evident, that the *denſe Part* of the *negative Atmoſphere of Air* round that wire, particularly round the Point N, will likewiſe be extremely ſmall (as is repreſented in Figure 6).

§ 44. Conſequently, the *Reſiſtance*, oppoſed by the *negative* Atmoſphere, at the Point N, to the *Entrance* of Electricity into the Body AB, will alſo be extremely ſmall. Therefore, the Electricity of the maſs of circumambient Air

GHKL (which conſtantly tends to ſupply the *deficient* Electricity of the *minus* electrified Body AB), will run into that *negative* Body AB, in a much *greater Quantity*, through the Point N, where the *Reſiſtance* is very *ſmall*; than it will through any *non-prominent* Point whatever, of the Body AB, where the *Reſiſtance* is of neceſſity, *conſiderable.*

§ 45. If, to a *negative* Body AB, a *round* metallick Body PQ be connected, and be made to *project* into the Air, which ſurrounds that Body AB (that is equal and ſimilar to the Bodies repreſented in Figures 5 and 6), in the ſame manner, that the *pointed* metallick wire MN was made to project: it may be aſked what the reaſon is, that the *ſame Effect* does *not* take place, as in the other caſe? Fig. 7.

§ 46. The reaſon is ſimply this. The greater the *Surface* of the prominent Body is; the more conſiderable will the *negative Atmoſphere* be, which ſurrounds that prominent *minus* Body PQ. From this it is evident, that the greater the *Surface* of the prominent Body is; the greater will the *Reſiſtance* be, which is oppoſed to the *Entrance* of the Fluid, that tends to ſupply the *deficient* Electricity of the Body AB; and the ſmaller will the *Quantity* of electrical Fluid be, which can *gradually* run in, through the *prominent* Body, from the maſs of circumambient Air.

§ 47. From what has been here ſaid, it muſt appear, that the *Property which prominent metallick Points have,* *to unelectrify gradually* the charged Bodies to which they are fixed, does *not* depend upon their being of a *conical* or of a *pyramidical form*; but upon their *projecting* beyond the electrified Bodies, to which they are (by a good communication) connected; and alſo, upon the *ſmall Quantity of Surface* which they have *in contact* with the Air.

§ 48. Therefore, the *greater that Projection*; the *ſmaller the Surface* of the metallick Point; and the *more tapering* the upper Extremity of the conducting Rod be made; the more conſiderable will the *power* of that *pointed* Rod be, *to unelectrify gradually* the charged Body with which it is properly connected.

§ 49. Theſe Principles are moſt fully confirmed, by *all* electrical Experiments upon *Points*, *Balls*, &c. and particularly by that very curious *Phenomenon*, of a *pointed* wire R, which, by being only placed *between* two *prominent* and *round* metallick Bodies S and T, can act *no longer like a Point*, or only in a *very ſmall* degree; on account of the *denſe Part*, of the *electrical Atmoſphere* of thoſe Bodies, being extended over it. Fig. 8.

§ 50. The learned Mr. *Archard* (of *Berlin*), as I have lately been informed, has made, with a prodigious degree of accuracy, a great number of Experiments; in order to determine, what were the *Times* of diſcharge, and the *relative Quantities* of Electricity that would be *ſilently diſcharged*, from an electrified Prime-Conductor†, by means of metallick Bodies of *different Terminations*, placed at *different Diſtances* from that charged Body.

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† A glaſs Globe and a *Leyden* Bottle were made uſe of, to charge the Prime-Conductor.

He made uſe, in *one* ſet of Experiments, of an *upright Cone* of braſs, whoſe vertex was extremly *acute*; whoſe height was *one inch and an half*, and the diameter of whoſe Baſe was *one inch*.

§ 51. In a *ſecond* ſet of Experiments, he made uſe of a flat circular Plate of braſs, of *one inch* diameter; upon which Plate he ſcrewed at once *nine Cones:* the height of each of theſe nine Cones was *one inch and an half*, and the diameter of the Baſe of each, was about *one twelfth of an inch*.

§ 52. In a *third* ſet of Experiments, he made uſe of the ſame flat circular Plate of Braſs, upon which he ſcrewed only *one* of the nine Cones, juſt mentioned. This Cone differed from the other Cone that he made uſe of in his *firſt* ſet of Experiments, only in *one* reſpect, viz. in being *more finely tapered*; the diameter of its Baſe, being only about *one twelfth* † *Part* of the diameter of the Baſe of the other Cone; but their heights were *equal*.

§ 53. When Mr. *Archard* compared the reſults of theſe *three* ſets of Experiments, he found that the *ſingle Point* (for ſo he calls the *tapering Cone)* did *ſilently diſcharge*, in a given Time, a *greater Quantity* of electrical Fluid from the charged Prime-Conductor, than did, either the *other leſs tapering Cone*, or even the *nine Points* that were fixt at once upon the *ſmall* braſs Plate; which Effect, he ſays, appears to him to be *very extraordinary* indeed.

§ 54.

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† See § 50 and § 51.

§ 54. But this Effect, ſingular as it may appear, is evidently a *neceſſary conſequence* of the plain *Principles* I have laid down above (from § 30, to § 49 incluſively).

§ 55. Now, in order to ſee in what manner, a Body, which is of any *given ſhape*, and which is a *good conductor* of the electrical Fluid, muſt be affected, when it is immerged in an *electrical Atmoſphere*; let us ſuppoſe, Fig. 9. that a metallick Body AB, which has no *prominent* Parts, be inſulated, and that its *near* End A, be placed within the ſenſible Part of the *electrical Atmoſphere* of a charged Prime-Conductor PC, but out of its *ſtriking Diſtance*.

§ 56. This is always poſſible; ſince, from the very nature of an *electrical Atmoſphere*, and of a *ſtriking Diſtance* (as explained above, § 19, § 28 and § 29), it is univerſally true, that the ſenſible Part of any charged Body's *electrical Atmoſphere*, does conſtantly extend much beyond the Diſtance, at which any *ſecond* Body, of any ſhape, or of any ſize, or placed under any circumſtances, can receive any *direct Stroke* of Exploſion, immediately from, or can give any *direct Stroke* of Exploſion, immediately to, that *firſt* Body thus charged with Electricity. The caſe even of a *Leyden Jar* is not excepted.

§ 57. The *electrical Atmoſphere* of the Prime-Conductor PC, muſt of neceſſity, be either *negative* or *poſitive*. Firſt, let us ſuppoſe it to be *negative*, and let us examine what will be the conſequence, with reſpect to the metallick Body AB, in the caſe before us.

§ 58.

§ 58. We have ſeen above (§ 20 and § 21), that the *Denſity* of all electrical Atmoſpheres does decreaſe, the more the *Diſtance* from the electrified Body is increaſed. Therefore, *more* of the Particles of the *minus* Atmoſphere of the Prime-Conductor PC, will be *ſuperinduced* upon the *near* End (or Side) A, of the Body AB, than upon the *remote* End B; even ſuppoſing the End B, to be much within the ſenſible Part of the electrical Atmoſphere of the Prime-Conductor PC.

§ 59. Conſequently, from the very nature of an *electrical Equilibrium*, a certain Part of the *natural Quantity* of electrical Fluid contained in the *remote* End B, of the Body AB (by attempting to ſupply ſome of the *deficient* Electricity of the *negatively* electrified Particles of *Air*, which conſtitute the *electrical Atmoſphere* of the Prime-Conductor PC, *ſuperinduced* upon the *near* End A), muſt of neceſſity, crowd towards the *near* End A, and endeavour to get out there.

§ 60. Now, *that Part* of the electrical Fluid of the Body AB, which has (as I have juſt ſaid) a neceſſary tendency to get out at the End A, will be prevented from leaving the *inſulated* Body AB, as it will meet with a conſiderable Degree of *Reſiſtance* at the *Surface* of that Body; the dry *Air* round about, being a *non-conductor* of Electricity.

§ 61. Therefore, the electrical Fluid, that removed from the *remote* End B, towards the *near* End A, will cauſe that End A (which was before in its *natural* ſtate) to become *poſitive*.

§ 62. Conſequently, the *remote* End B (which was alſo *unelectrified*, before the motion of the electrical Fluid, on the ſurface of the Body AB, took place) will now evidently be left in a *negative* ſtate; ſince, a Part of its *natural* ſhare of electrical Fluid did remove towards the *other* End A.

§ 63. There will likewiſe be, between the End A, and the End B (of the Body AB), a certain *Point* D, where theſe two *contrary* Electricities, of the different Ends A and B, will meet; and where conſequently, the Body AB will be in its *natural* ſtate; that is to ſay, neither *poſitively* nor *negatively* electrified.

§ 64. Having then examined what muſt follow, from the *electrical Atmoſphere* of the Prime-Conductor PC being *negative:* let us next conſider, what alterations would take place in the electrical Fluid of the Body AB; ſuppoſing the Prime-Conductor's electrical Atmoſphere to be *poſitive.*

§ 65. From what I have ſaid above (§ 20 and § 21), it follows, that *more* of the Particles of the *plus* Atmoſphere of the Prime-Conductor PC, will be *ſuperinduced* upon the *near* End (or Side) A, of the Body AB, than upon the *remote* End B.

§ 66. Therefore, from the very nature of an *electrical Equilibrium*, a certain Part of the *natural Quantity* of electrical Fluid, contained in the *near* End A, muſt neceſſarily remove towards the *remote* End B.

Becauſe, the *elaſtick electrical Fluid*, which is contained in the Prime-Conductor's electrical Atmoſphere, and which is *ſuperinduced* upon the *near* End A; muſt (by preſſing againſt it, and tending to enter), neceſſarily tend alſo to remove a Part of the *elaſtick electrical Force* which oppoſes its Entrance.

§ 67. That is to ſay, that it muſt tend to remove, towards the *remote* End B (of the inſulated Body AB), a Part of the *natural Quantity of electrical Fluid*, contained in the *near* End A: ſince, the *elaſtick electrical Force*, oppoſed at the Surface of the metallick Body AB, does immediately proceed from the *natural ſhare of electrical Fluid* therein contained.

§ 68. Now, that Part of the electrical Fluid of the Body AB, which (as I have juſt ſaid) was removed, from the *near* End A, to the *remote* End B, will be prevented from leaving the inſulated Body AB, as it will meet with a conſiderable Degree of *Reſiſtance* at the *Surface* of that Body; the dry *Air* round about, being a *non-conductor* of Electricity.

§ 69. Therefore, the electrical Fluid, that removed from the *near* End A, towards the *remote* End B, will cauſe that End B (which was before in its *natural* ſtate) to become *poſitive*.

§ 70. Conſequently, the *near* End A (which was alſo *unelectrified*, before the motion of the electrical Fluid, on the Surface of the Body AB, took place), will now evidently be left in a *negative* ſtate; ſince, a Part of its *natural* ſhare of electrical Fluid did remove towards the *other* End B.

§ 71. There will likewiſe be, between the End A, and the End B, of the Body AB, a certain *Point* D, where theſe two *contrary* Electricities, of the different Ends A and B, will meet, as in the former caſe; and where conſequently, the Body AB, will be in its *natural* ſtate; that is to ſay, neither *poſitively* nor *negatively* electrified.

§ 72. It appears therefore, to be a *general* Rule; if there be brought, within the *plus* or *minus* electrical Atmoſphere of a charged Body, any *ſecond* Body, which is a good *Conductor* of Electricity, and which is ſo circumſtanced (in the manner above explained), as *not* to be able either to *loſe*, or to *acquire*, any electrical Fluid:

1*ſt*, That, the *near* End (or Side) of the *ſecond* Body, will become electrified, with the *contrary* Electricity, to that of the *firſt* Body, which produces the electrical Atmoſphere.

2*dly*, That, the *remote* End (or Side) of the *ſecond* Body, will become electrified with the *ſame* kind of Electricity, as that of the *firſt* Body.

And 3*dly*, That there will be, between the two oppoſite Ends of the *ſecond* Body, a *certain Point* where there will be neither *plus* nor *minus* Electricity.

§ 73. So that, the *ſecond* Body will be in *three oppoſite ſtates*, at one and the ſame time. That is to ſay, that it will be, at the ſame inſtant, *poſitively* electrified, *negatively* electrified, and *not electrified at all*.

§ 74. Should any Perſon doubt of the truth of this Fact, the following Experiments will fully ſatisfy him about it.

PART II.

PART II.

SECTION 75.

IN order to ſave repetitions, and to be the more diſtinct, I will, for the future, ſpeak of the *Prime-Conductor* as being always electrified *in plus*; as nothing will be more eaſy, than for my expreſſions to be *reverſed* in a proper manner, by any attentive Reader, when he ſhall wiſh to conſider the Prime-Conductor as being *negatively* electrified.

EXPERIMENT 5.

§ 76. I made uſe, in the following Experiments, of a tin-foil Prime-Conductor, which was *ſix feet* long, by one foot diameter; and which had, at one End, a braſs neck (of four inches and a half long, by three quarters of an inch diameter), to the extremity of which, was fixed a braſs Ball, of four inches and an half diameter. The *ſtriking Diſtance* of this Prime-Conductor, upon a ſmooth braſs Ball of *four inches* diameter, that was connected with the Earth by a proper metallick communication, varied according to the weather, from *fifteen inches* to *eighteen inches and a quarter*, in the Experiments I made with this apparatus†.

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† This apparatus was made by the able Mr. *Edward Nairne*, F. R. S.

Fig. 9. § 77. I then placed a cylindrical braſs Conductor AB (which was perfectly well inſulated), with one End directly pointing towards the Prime-Conductor † PC.

This Body AB (including the *ſemi-Spheres* at its two Ends) was *three feet four inches* long, by about three inches and three quarters diameter.

§ 78. The Diſtance between the Prime-Conductor PC, and the *near* End A of the metallick Body AB, was generally about *three feet*; tho' that Diſtance was very often varied, as will be related hereafter.

§ 79. Whilſt the Prime-Conductor was charging, I approached towards it, a ſmall Cork-Ball, ſuſpended by a very fine thread of flax, and it was ſtrongly *attracted* (in the manner repreſented at E), towards the Prime-Conductor, which was then charged with *poſitive* Electricity.

EXPERIMENT 6.

§ 80. I then approached this ſimple Electrometer, towards the *near* End A, of the metallick Body AB, and it was ſtrongly *repelled* from it (in the manner repreſented at F); which ſhewed, that the *near* End A, of the Body AB, was charged with a *contrary* Electricity to that of the

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† The Prime-Conductor itſelf was not *always* placed, exactly in the ſame ſituation (in which it is repreſented in the Figure) with reſpect to the Body AB.

Prime-Conductor PC. That is to ſay, that the End A was (in this caſe) electrified *in minus*.

EXPERIMENT 7.

§. 81. Upon approaching the Electrometer towards the *remote* End B, of the Body AB, it was *attracted* (as repreſented at H); which ſhewed, that the *remote* End B, of the Body AB, was charged with the *ſame* kind of Electricity as the Prime Conductor PC. That is to ſay, that the End B was (in this caſe) electrified *in plus*.

EXPERIMENT 8.

§ 82. When the Electrometer was gradually moved, along the Body AB, from the End A where it was *repelled*, towards the End B where it was *attracted*; the Repulſion was found gradually to decreaſe, whilſt the Electrometer was moved from the *near* End A, to a certain *Point* D; at which Point D, the electrometrical Ball (repreſented at G) appeared to waver, and was neither *repelled* nor *attracted* by the metallick Body AB.

This Effect was particularly evident, when the *electrometrical Ball* was held on *one ſide* of the Body AB, and at a moderate Diſtance from it.

§ 83. Conſequently, the Body AB was in its *natural* ſtate, at the *Point* D. That is to ſay, that the Body

AB contained *there*, neither *more*, *nor leſs* than its *natural* ſhare of Electricity.

EXPERIMENT 9.

§ 84. When the Electrometer was moved along the Body AB, ſtill nearer to the *remote* End B; the electrometrical Ball became *attracted* by the Body AB, as ſoon as it had paſſed the *Point* D: and this *attraction* continued to increaſe, the nearer the Electrometer was brought to the End B, which was the moſt *remote* from the Prime Conductor.

§ 85. In order, to be able to ſatisfy thoſe who are not very converſant with Electricity, that there was no deception in theſe Experiments, I repeated Experiments of a like nature, in the following manner.

EXPERIMENT 10.

§ 86. I took a *pair* of Cork-Balls, ſuſpended by very fine, and parallel linnen threads, and I placed the Electrometer at a moderate Diſtance from the Prime-Conductor PC (as at K); but, entirely out of the ſenſible Part of the electrical Atmoſphere of the Body AB. The Cork Balls divaricated.

§ 87. I then approached towards the under ſide of the Balls, a ſtick of ſealing wax, that I had ſtrongly excited with a woollen cloth: this cauſed them to † divaricate *leſs.* Becauſe, the *negative* Electricity of a ſtick of wax (excited in the manner juſt mentioned), will always tend, as every one knows, to *counteract* and deſtroy the *poſitive* Electricity, of a *plus* electrified Prime-Conductor.

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† In repeating this Experiment, and the two following ones, there are *two* things, to which it is neceſſary to pay particular attention; namely, the exciting the ſtick of wax *ſtrongly*; and the not bringing the electrometrical Balls *too near* to the electrified Body, the *quality* of whoſe Electricity we want to examine.

For, if (from the too great *weakneſs* of the Electricity of the ſtick of wax; or from the too great *proximity* of the Electrometer, to the charged Body; ſuppoſing the Electricity of the charged Body to be *ſtrong*;) the ſtrength of the *electrical Atmoſphere* of the charged Body, and the ſtrength of the *electrical Atmoſphere* of the ſtick of wax, be *very different* with reſpect to the electrometrical Balls, given in poſition: then, the approaching the ſtick of wax toward the under ſide of the Balls, will, in *every caſe*, cauſe them to divaricate *wider*; inſtead, of cauſing them to divaricate, ſometimes *more*, and ſometimes *leſs*, according as the charged Body is *negatively* or *poſitively* electrified.

Becauſe, when the excited Electricity of the ſtick of wax, is very *weak*, compared to the communicated Electricity of the charged Body, the ſtick of wax will act, in all appearance, as if it was *not electrified at all.* The conſequence of which muſt be, that the ſtick of wax will (like any *unelectrified* non-conducting Body), by being brought near to the under ſide of the electrometrical Balls, cauſe thoſe Balls (if they are very *ſtrongly electrified*), to be *repelled*, and to divaricate *wider*; whether they divaricated originally, from *negative*, or from *poſitive* repulſion.

The reaſon of this Effect is; that, if any *unelectrified*, and *non-conducting* Body, be very dry, and be brought within any Atmoſphere ſtrongly electrified (whether in *plus* or in *minus*), it will not be able to *carry off* the Electricity, of that electrical Atmoſphere.

Conſequently, (from the Principle laid down above § 22,) the *charged Body* producing that electrical Atmoſphere, and the *non-conductor* therein immerged, muſt, under thoſe circumſtances, tend to *recede* from each other.

EXPERIMENT 11.

§ 88. I then placed the Electrometer at a moderate Diſtance from the *near* End A, of the inſulated metallick Body AB (as at L). The Balls divaricated.

§ 89. ~~I then approached the excited ſtick of ſealing~~ wax, towards the under ſide of them, which cauſed them to divaricate ſtill *more.*

§ 90. This was a proof, that the *End* A (of the Body AB), that was the *neareſt* to the *plus* electrified Prime-Conductor PC, was electrified with the *ſame* kind of Electricity as the ſtick of wax; ſince, in this caſe, the Electricity of the ſtick of wax *co-operated* with the Electricity of the *near* End A (of the Body AB), in cauſing the electrometrical Balls to divaricate.

That is to ſay, that the *near* End A, of the Body AB, was *negative.*

EXPERIMENT. 12.

§ 91. I then placed the Electrometer, at a moderate Diſtance from the *remote* End B, of the inſulated metallick Body AB (as at M). The Balls divaricated.

§ 92. I then approached the excited ſtick of ſealing wax, towards the under ſide of them, which cauſed them to divaricate *leſs*.

§ 93. This was a proof, that the *End* B (of the Body AB), that was the *moſt remote* from the *plus* electrified Prime-Conductor PC, was electrified with the *contrary* Electricity to that of the ſtick of wax.

§ 94. That is to ſay, that the *remote* † *End* B, of the Body AB, was electrified *in plus*, the ſame as the Prime-Conductor PC; altho' the *other* † *End* A (of this ſame Body AB) which was the *neareſt* to that *poſitively* electrified Prime-Conductor PC, was, as we have juſt ſeen, charged with *negative* Electricity.

Nothing can poſſibly be more evident than this.

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† Theſe things agree perfectly, with the reſults of the Experiments made by the learned Signior *Beccaria*, by *Wilcke*, by *Æpinus*, &c.

PART III.

SECTION 95.

I Shall, in the following Pages, ſhew how to determine, with mathematical preciſion, the *Ratio*, between the *Quantity of electrical Fluid* (of any charged Body's electrical Atmoſphere) *ſuperinduced* upon an inſulated, conducting Body of any form whatever, and the *plus* or *minus* Electricity of the *oppoſitely-electrified Portions* of that inſulated Body. And I ſhall prove, that the *neutral* or *unelectrified Point* of that Body, muſt always exactly *coincide* with the *Plane* that would divide, into *two equal Portions*, the whole Quantity of ſuperinduced Electricity.

The conſequences to be drawn from theſe things, will hereafter appear to be of very great importance.

EXPERIMENT 13.

Fig. 9. § 96. When the inſulated Body AB † above-mentioned, was in its ſtate of *three-fold* Electricity, in the manner deſcribed above (§ 72 and § 73); having one End *plus*, the other *minus*, and another Part *unelectrified:* I totally diſcharged the Prime-Conductor of its Electricity; having previouſly ſtopt the wheel and cylinder, in order, to prevent any further ſupply of Electricity being given to the Prime-Conductor, after it had become diſcharged.

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† § 77, & ſeq.

Then, upon examining the ſtate of the Body AB, I found that Body to be in its *natural* ſtate; that is to ſay, *unelectrified* throughout.

EXPERIMENT 14.

§ 97. If, inſtead of diſcharging the Prime Conductor PC of its Electricity, I removed the Body AB (in its inſulated ſtate), out of the *electrical Atmoſphere* of the Prime-Conductor; the Body AB was always ſound to be in its *natural* ſtate; that is to ſay, *unelectrified* throughout.

§ 98. The reaſon, why the metallick Body AB did return to its *natural* ſtate, was evident. For, as ſoon, as the *electrical Atmoſphere* of the Prime-Conductor PC was removed, either by the *diſcharge* of the Prime-Conductor's Electricity, or by the *removal* of the Body AB itſelf; the *electrical Fluid*, which had, as was above-explained, been driven out of one End A, of the Body AB, into the other End B (by the elaſtick electrical *preſſure* of that electrical Atmoſphere *ſuperinduced* upon the Body AB), did then neceſſarily *return* from the End B, to the End A: ſince, the elaſtick *Cauſe*, which had diſturbed the *natural Equilibrium*, was then actually removed.

§ 99. It is evident, from theſe Experiments; that, the inſulated Body AB, had neither *loſt*, nor *acquired* Electricity, by having been *immerged* into the *electrical Atmoſphere* of the Prime-Conductor PC: but, that it had become *electrified*, only by having had the electrical Matter, *contained within itſelf*, *diſturbed*; when its two Ends appeared ſo ſtrongly affected with *contrary* Electricities.

§ 100. From this, it evidently follows, that the Quantity of *minus* Electricity, contained in the Part AD (of the Body ADB) which was between the *near* End A, and the *neutral Point* D (at which Point D, the Body ADB was in its *natural* ſtate, as explained above, § 63, § 71, § 72, § 82 and § 83), muſt have been *exactly equal* to the Quantity of *plus* Electricity, contained in the other Part DB, which was between the ſame *neutral Point* D and the *remote* End B, of that inſulated metallick Body AB.

§ 101. Now, whatever be the *Law*, according to which, the *Denſity* of the Electricity, of an electrical Atmoſphere, does decreaſe: whatever be the *Quantity* † of electrical Fluid (of any electrical Atmoſphere) *ſuperinduced* upon any inſulated conducting Body; which *Body*, for diſtinctneſs I will call AB: whatever be the *form*, or whatever be the *poſition*, of the inſulated conducting Body AB, that is thus immerged in the electrical Atmoſphere; provided that *form*, or that *poſition*, be *not* ſuch, as to cauſe this *trebly-electrified* Body AB, to *loſe* any of its *own*

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† Whenever I ſpeak of the *Quantity* of *electrical Fluid, ſuperinduced* upon a given Body, or upon any given Parts of a Body; I mean, to be always underſtood to ſpeak of the *total Quantity of plus*, or of the *total Quantity of minus Electricity, contained in that particular Part*, of the electrical Atmoſphere, which is *ſuperinduced* upon the whole Surface, of the given Body, or of the given Parts of the Body, reſpectively. Becauſe, it is *not any Part of the natural Share of Electricity*, contained in the ſuperinduced electrical Atmoſphere; but, only the *poſitive*, or the *negative Electricity*, therein contained, that can tend to act (in the manner above-deſcribed) upon any inſulated, *unelectrified*, conducting Body, immerged in that electrical Atmoſphere.

In like manner, if I ſpeak of the *Denſity of the Electricity*, of an electrified Body, or of an electrical Atmoſphere; I always mean the *Denſity of the plus*, or *of the minus Electricity*, contained in ſuch Body, or in ſuch Atmoſphere.

own electrical Fluid, or to *acquire* any more than its *natural ſhare* of Electricity: and whether the *electrical Atmoſphere*, in which, this inſulated, conducting Body AB is immerged, be *negative*, or *poſitive*: it will, from the nature of the *electrical Fluid*, be univerſally true;

1*ſt*. That the *Force* or *Power* of the *minus* Electricity, contained in the negative Portion of the Body AB, will be equal to the *mean Denſity* of that *minus* Electricity, multiplied into the *Height* of that *minus* Electricity, multiplied alſo into the *Baſe* of that *minus* Electricity.

And 2*dly*, That the *Force* or *Power* of the *plus* Electricity, contained in the poſitive Portion of the Body AB, will be *equal* to the *mean Denſity* of that *plus* Electricity, multiplied into the *Height* of that *plus* Electricity, multiplied alſo into the *Baſe* of that *plus* Electricity.

§ 102. We have ſeen above (§ 99 and § 100); that, a Body [ſuch as AB] charged with a *three-fold* Electricity, becomes *electrified*, *only* by having the electrical Matter, *within itſelf*, diſturbed: and that, conſequently, the *Quantity* of *minus* Electricity contained in the negative Portion, is exactly *equal* to the *Quantity* of *plus* Electricity contained in the poſitive Portion; which is to ſay, in other Words, that the *mean Denſity* of the ſaid *minus* Electricity, multiplied into the Height † of that *minus* Electricity, is exactly *equal* to the *mean Denſity* of the ſaid *plus* Electricity, multiplied into the *Height* of that *plus* Electricity.

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† It is evident, that the *Height* of the ſaid *minus* Electricity, is the *Length* of the ſaid *negative* Portion; and that the *Height* of the ſaid *plus* Electricity, is the *Length* of the ſaid *poſitive* Portion. Therefore, the *mean Denſity* of the ſaid *minus* Electricity, muſt be, to the *mean Denſity* of the ſaid *plus* Electricity, in the exact *inverſe Ratio* of the *Length* of the *negative* Portion, to the Length of the *poſitive* Portion.

But, the *Baſe* of the ſaid *minus* Electricity, and the *Baſe* of the ſaid *plus* Electricity, is *common*; that *Baſe* being the *Line*, where thoſe two *contrary* Electricities, of the Body AB, *meet*, and *join* each other, upon the Surface of the Body AB.

Conſequently, the *Force* or *Power* of the *minus* Electricity contained in the *negative* Portion of the Body AB, muſt (from what was laid down above, in § 101) be exactly *equal* to the *Force* or *Power* of the *plus* Electricity contained in the *poſitive* Portion of that Body AB.

§ 103. Now, ſince, it is the elaſtick electrical Fluid *ſuperinduced* upon the ſaid Body AB, that cauſes the electrical Fluid of the Body AB, to be diſturbed *within that Body* itſelf: it is evident, that; if we ſuppoſe the *whole Quantity of electrical Fluid*, *ſuperinduced* upon the whole Surface of the Body AB, to be *divided* by a *Plane* (drawn perpendicular to the *right Line* that would join the inſulated Body AB, and the charged Body producing the *ſuperinduced* electrical Atmoſphere) exactly into *two equal* Portions, which Portions I will call *a* and *b*; it will follow,

1ſt. That the *mean Denſity* of the Electricity *ſuperinduced* on the *Portion a*, of the Body AB; will be, to the *mean Denſity* of the Electricity (*ſuperinduced* on the *two Portions a and b*; that is to ſay,) *ſuperinduced* on the *whole Surface* of the Body AB; in the *ſame Ratio*, as $\frac{\text{the Length of } a + \text{the Length of } b}{2}$ is to the Length of *a*.

And 2*dly*. That the *mean Denſity* of the Electricity *ſuperinduced* on the *Portion b*; will be, to the *mean Denſity* of the Electricity *ſuperinduced* on the *whole Surface* of the Body AB; in the *ſame Ratio*, as $\frac{\text{the Length of } a + \text{the Length of } b}{2}$ is to the Length of *b*.

§ 104. Therefore, from theſe things, and from the very nature of a *diſturbed electrical Equilibrium* in a Body charged with a *three-fold* Electricity as above explained; it evidently follows,

1*ſt*. That the *mean Denſity* of the Electricity *ſuperinduced* on the *whole Surface* of the Body AB, multiplied into the *Difference* between $\frac{\text{the Length of } a + \text{the Length of } b}{2}$ and the Length of *a*, muſt be exactly *equal* to the *Quantity* of *minus* [or of *plus*] Electricity contained in that *Portion a*.

And 2*dly*. That the *mean Denſity* of the Electricity *ſuperinduced* on the *whole Surface* of the Body AB, multiplied into the *Difference* between $\frac{\text{the Length of } a + \text{the Length of } b}{2}$ and the Length of *b*, muſt be exactly *equal* to the *Quantity* of *plus* [or of *minus*] Electricity contained in that *Portion b*.

§ 105. But, the *Difference* between $\frac{\text{the Length of } a + \text{the Length of } b}{2}$ and the Length of *a*, is evidently exactly *equal* to the *Difference* between $\frac{\text{the Length of } a + \text{the Length of } b}{2}$ and the Length of *b*.

And the *mean Denſity* of the Electricity *ſuperinduced* on the *whole Surface* of the Body AB is (as it has been ſtated above, in § 104) the *common Factor* of theſe *two equal* Quantities.

Therefore, it is evident; that, the *minus* [or *plus*] Electricity contained in the *Portion a*, of the Body AB, muſt (by the firſt Axiom of Euclid) be exactly *equal* to the *plus* [or *minus*] Electricity contained in the other *Portion b.*

That is to ſay, in other words, that *the Plane, which divides into two equal Parts, the whole Quantity of electrical Fluid ſuperinduced upon the whole Surface of the ſaid Body* AB, will alſo divide the Electricity *contained in the Body* AB itſelf, in ſuch a manner, that the *minus* [or *plus*] Electricity on *one ſide* of that Plane, will be exactly *equal* to the *plus* [or *minus*] Electricity on the *other ſide* of that dividing Plane.

§ 106. But, I have ſhewn above (§ 100), that it is likewiſe the property of the *neutral* or *unelectrified Point*, to divide the Electricity *contained in the Body* AB, in ſuch a manner, that the *minus* [or *plus*] Electricity on *one ſide* of the *neutral Point*, ſhould be exactly *equal* to the *plus* [or *minus*] Electricity on the *other ſide* of that *neutral Point.*

§ 107. Conſequently, the *Plane*, which (if drawn, in the manner above-deſcribed § 103) would divide into *two equal Parts, the whole Quantity of electrical Fluid, ſuperinduced upon the whole Surface* of any inſulated conducting Body AB, immerged in an electrical Atmoſphere; muſt, of neceſſity, *exactly coincide* with the *neutral* or *unelectrified Point*, where the two *contrary* Electricities of that Body AB, will meet, and deſtroy each other.

That is to ſay, it muſt *exactly coincide with that Point*, thro' which, if a *Plane* were drawn (perpendicular to the *right Line*, that would join the charged Body producing the electrical Atmoſphere, and the inſulated, conducting Body AB therein immerged); *ſuch Plane* would divide that

Body AB, immerged in the electrical Atmoſphere, into *two* certain Parts; in ſuch a manner, that one of them ſhould contain, nothing but *negative*, and the other, nothing but *poſitive* Electricity. Provided always, that the Body AB be electrified in the manner deſcribed above (§ 99), *only* by having the electrical Fluid, *within itſelf*, diſturbed.

PART IV.

SECTION 108.

FROM what has been ſaid in the laſt Section, it is evident; that, in order to determine, in any caſe whatever, the *Poſition of the neutral or unelectrified Point*, in *any* given inſulated conducting Body AB, which Body AB, by being immerged in the electrical Atmoſphere of any charged Body PC, does become electrified by its *own diſturbed Electricity*, in the Manner above-deſcribed (§ 99); it will be neceſſary, *only* to determine the *Poſition of the Plane*, which (if drawn in the Manner deſcribed above (§ 103), would divide into *two equal* Parts, the *whole Quantity of electrical Fluid* (of the charged Body PC's electrical Atmoſphere) *ſuperinduced* upon the *whole Surface* of the ſaid inſulated conducting Body AB.

§ 109. Now, it is evident, that the *Poſition of this Plane*, which (if drawn, in the Manner above deſcribed, § 103), would divide into *two equal* Parts, *the whole Quantity of electrical Fluid* (of the charged Body PC's electrical Atmoſphere) *ſuperinduced* upon the *whole Surface* of any given inſulated conducting Body AB; will neceſſarily depend, upon the *Form* of the Body, that is immerged in the electrical Atmoſphere; and upon the *Law*, according to which, the *Denſity of the Electricity*, of electrical Atmoſpheres, does decreaſe.

§ 110. Firſt, let us ſuppoſe, the *Denſity of the Electricity*, of the electrical Atmoſphere, to be in the *ſimple inverſe Ratio of the Diſtance* from the charged Body PC, which produces that electrical Atmoſphere.

The other Body AB, therein immerged, being ſuppoſed Fig. 9.
to be (for example) of a *cylindrical* † *Form*; having one
End A, directly pointing towards the charged Body PC.

§ 111. Now, it is a well known Property of every coni-
-cal *Hyperbola*; that any Line AN, drawn parallel to one Fig. 10.
Aſymptote CO, between the Curve, and the other Aſymptote CB; will be, to every other Line (DR, or ST, or BQ, &c.) ſimilarly deſcribed, in the exact *ſimple inverſe Ratio of their reſpective Diſtances* (AC, CD; or AC, CS; or AC, CB, &c.) from the Center C, of the Hyperbola.

§ 112. Therefore, according to the *Law* juſt ſuppoſed (§ 110) the *Quantity of Electricity* (of the charged Body PC's electrical Atmoſphere) *ſuperinduced* upon the
curved Surface of the inſulated cylindrical Body AB, at Fig. 9.
the particular *Diſtances* CA, CD, CS, CB, &c. from
that charged Body PC; will be exactly proportional, to
the reſpective *Ordinates* AN, DR, ST, BQ, &c. of any Fig. 10.
equilateral *Hyperbola* NRQ; one of whoſe Aſymptotes
CO is a Tangent, to the charged Body PC, at C. Fig. 9.

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† N. B. The *curved Part* only, of the Surface of the ſaid Cylinder, is to be taken into conſideration.

§ 113. Conſequently, according to the Law juſt ſuppoſed (§ 110), the *whole Quantity of Electricity* (of the Fig. 9. charged Body PC's electrical Atmoſphere) *ſuperinduced* upon the *curved Part* of the Surface, of the inſulated cylindrical Body AB, will be accurately repreſented by the *Area* of the *hyperbolical Space* ANQB (Figure 10), which is bounded by the Curve NRQ, the Aſymptote CB, and the two Ordinates AN and BQ, which Ordinates are Tangents to the Body AB (Figure 9), at its Ends A and B, reſpectively.

§ 114. Now, in order to determine the Poſition of the *neutral*, or *unelectrified* Point, in Figure 9; it will be ſufficient (as appears from what has been ſaid above, § 108 and § 113), to find out *the Point* D, upon the Aſymptote CB, in Figure 10, through which Point, a *right Line* DR, drawn parallel to the other Aſymptote CO, would divide the *hyperbolical Area* ANQB, into *two equal* Portions; ſuch as ANRD, and RDQB: ſuppoſing the *Denſity of the Electricity* (of the Electrical Atmoſphere) *ſuperinduced* upon the Body AB, to be, in the *ſimple inverſe Ratio of the Diſtance* from the charged Body PC.

§ 115. The Way to divide the *hyperbolical Area* Fig. 10. ANQB, into *two equal* Portions, is ſimply as follows.

Take DR, a *geometrical mean-proportional* between the two *Ordinates* AN and BQ: that is to ſay, take the *Point* D, ſo that, AN, be to DR; as RD, to BQ. Or (which, from the nature of the Hyperbola, is the ſame thing), take the *Abſciſſes*, BC, to CD; as DC, to CA.

Through this *Point* D, parallel to the Aſypmptote CO; draw DR, meeting the Curve in R. Then, the *hyper-*

-*bolical Area* ANQB, will thereby, be divided into *two equal* Portions, ANRD, and DRQB; as required.

DEMONSTRATION.

§ 116. If it be denied, that the two *hyperbolical Areas* ANRD, and DRQB are *equal*: let DRQB be ſuppoſed to be the *ſmaller* of the two: and let the *Polygon* DRLTQB be ſuppoſed to be *equal* to the *hyperbolical Area* ANRD.

§ 117. Through the Points L, and T; draw the Ordinates LM, and TS; meeting the Aſymptote CB, in M, and S.

Take AE, to DM; and EI, to MS; as DC, to CB; or (which, by the conſtruction, § 115, is the ſame thing,) as AC, to CD.

§ 118. It is evident, that;

DC-CA (*i. e.* AD): BC-CD (*i. e.* DB) : : AC : CD.

It is alſo evident, that;

AE+EI (*i. e.* AI) : DM+MS (*i. e.* DS) : : AC : CD.

Therefore,

DA-AI (*i. e.* DI) : BD-DS (*i. e.* BS) : : AC : CD.

§ 119. Through the Points E and I; draw the Ordinates EK, and IH, meeting the Curve, in K, and H.

Through the Points K, and L; draw the right Lines KG, and LF, parallel to the Aſymptote BC. Join the Points N, K; K, H; and H, R.

§ 120. By conſtruction (§ 117) MD : EA :: DC : CA.
Therefore,
MD+DC (*i. e.* MC) : EA+ AC (*i. e.* CE) :: DC : CA.
Conſequently, from the nature of the Hyperbola;
EK : ML :: (MC : CE *i. e.* :: DC : CA *i. e.* ::) DM : AE.
Therefore, the *Rectangle* AGKE=the *Rectangle* DFLM.

§ 121. Now, ſince EK : ML (:: DC : CA, *i. e.* by the nature of the Hyperbola) :: AN : DR.
It follows, that;
RD : NA(:: ML:KE *i. e.*) :: DF : AG :: AC : CD.
Therefore,
RD−DF (*i. e.* RF) : NA−AG (*i. e.* NG) :: AC : CD.

§ 122. But, by conſtruction (§ 117),
(EA or) KG : (MD or) LF :: AC : CD.
Conſequently, KG : LF :: FR : GN.
Therefore, KG×GN=LF×FR; and $\frac{KG\times GN}{2}=\frac{LF\times FR}{2}$.
That is to ſay, that the *Triangle* KGN=the *Triangle* LFR.

§ 123. But, it was proved above, § 120;
That, the *Rectangle* AGKE=the *Rectangle* DFLM.
Therefore,
The *Quadrilateral* ANKE=the *Quadrilateral* DRLM.

§ 124. In like manner, it may be demonſtrated; that, the *Quadrilateral* EKHI=the *Quadrilateral* MLTS;
And that, the *Quadrilateral* IHRD= the *Quadrilateral* STQB.

§ 125. Therefore,

The *whole Polygon* ANKHRD= the *whole Polygon* DRLTQB.

But, the *Polygon* DRLTQB, is (by hypotheſis, § 116,) = the *hyperbolical Area* ANRD.

Therefore, (by the firſt Axiom of Euclid,)

The *Polygon* ANKHRD= the *hyperbolical Area* ANRD; which is evidently abſurd.

Conſequently, the *hyperbolical Area* DRQB, is *not leſs* than the *hyperbolical Area* ANRD.

§ 126. In like manner, it may be demonſtrated; that, the *hyperbolical Area* ANRD, is *not leſs* than the *hyperbolical Area* DRQB.

Conſequently, the two *hyperbolical Areas* ANRD, and DRQB, are *equal* to each other.

That is to ſay, that the *Ordinate* DR, drawn through the *Point* D, divides the *hyperbolical Area* ANQB, into two *equal Parts*. Q^d. E^t. D^m.

§ 127. It is therefore evident, from what has been ſaid above (§ 114 and § 115), if *the Denſity of the Electricity*, of electrical Atmoſpheres, be in the *ſimple inverſe Ratio of the Diſtance*; that, the *neutral* or *unelectrified Point* D, (where, any inſulated trebly-electrified cylindrical † metallick Body AB, immerged in an electrical Atmoſphere, muſt be in its *natural* ſtate;) will always be determined, Fig. 9.

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† N. B. The *curved Part* only, of the Surface of the ſaid Cylinder, being taken into conſideration.

by taking the Line CD, a *geometrical mean-proportional* between the Lines AC and CB; which Lines repreſent the Diſtance, of the charged Body PC (producing the electrical Atmoſphere), from the Ends A, and B, of the Body AB, reſpectively.

§ 128. *N. B.* It is alſo evident, that the finding the Fig. 10. *Point* D, depends upon the *Ratio*, between certain *hyperbolical Ordinates*; and upon the *Ratio*, between the correſponding *Abſciſſes*; and *not* at all, upon the *abſolute Size* of the Hyperbola NRQ, or *n r q*.

So that, the *poſition* of the Points C, A, D, and B (upon the Aſymptote CB), will be exactly the *ſame*; whether the Hyperbola NRQ, or an Hyperbola *n r q*, of any other *Size*, be made uſe of.

PART V.

PART V.

SECTION 129.

I Shall now, in the next place, proceed to ſhew in what manner, the *neutral* or *unelectrified Point* is to be determined, if the *Denſity of the Electricity*, of an electrical Atmoſphere, were ſuppoſed to be (not *inverſely as the ſimple Diſtance*, according to our former Hypotheſis; but,) *inverſely as the ſquare of the Diſtance* from the charged Body PC, that produces the electrical Atmoſphere.

§ 130. Now, it is a known property, of every *infinite acute hyperbolick Solid*, ſuch as *nNZz*, (formed by the *revolution* of a conical *hyperbolick Space* ANZW, round an Aſymptote CB, as Axis;) that, the *Area*, of any *perpendicular circular Section* repreſented by *n*AN; will be, to the *Area*, of any other *perpendicular circular Section* repreſented by *r*DR, or *t*ST, or *q*BQ, &c. *inverſely as the ſquares of their reſpective Diſtances* (AC, CD; or AC, CS; or AC, CB; &c.) from the Center C, of the Hyperbola NRQ. Fig. 11.

§ 131. Therefore, according to the *Law* juſt ſuppoſed (§ 129), the Quantity of Electricity (of the charged Body

Fig. 9. PC's electrical Atmoſphere) *ſuperinduced* upon the *curved Surface* of the inſulated cylindrical Body AB, at the Diſtances, CA, CD, CS, CB, &c. from that charged Body PC; will be exactly *proportional to the Areas, of the reſpective perpendicular circular Sections* repreſented by Fig. 11. *n*AN, *r*DR, *t*ST, *q*BQ, &c. which Circles are reſpectively deſcribed, by the *revolution* of the perpendicular *hyperbolical Ordinates* AN, DR, ST, BQ, &c. round the Aſymptote CB, as Axis.

§ 132. Conſequently, according to the *Law* juſt ſuppoſed (§ 129), the *whole Quantity of Electricity* (of the Fig. 9. charged Body PC's electrical Atmſophere) *ſuperinduced* upon the *curved Part* of the Surface, of the inſulated cylindrical Body AB, will be accurately repreſented by the *finite hyperbolick Solid n* NQ*q*, formed in a manner ſimilar to that above deſcribed (§ 130); and whoſe *Ends* A, and B (Figure 11), are at the *ſame* reſpective Diſtances AC, and CB, from the Center C, of the *Hyperbola* NRQ; as the two *Ends*, of the inſulated cylindrical metallick Body AB (Figure 9), are from the charged Body PC.

§ 133. Now, in order to determine the poſition of the *neutral*, or *unelectrified Point*, in Figure 9; it will be ſufficient (as appears from what has been ſaid above, § 108 and § 132), to find out *the Point* D, upon the Axis CB, of the *hyperbolick Solid n* NQ*q*, in Figure 11, through which Point, a *Plane r*DR, drawn perpendicular to the Axis CB, would divide the *hyperbolick Solid n* NQ*q*, into *two equal* Solids; ſuch as *n*NR*r*, and *r*RQ*q*: ſuppoſing the *Denſity of the Electricity* (of the electrical Atmoſphere) *ſuperinduced* upon the Body AB, to be *inverſely as the ſquare of the Diſtance.*

§ 134. The way to divide the *hyperbolick Solid n*NQ*q*, Fig. 11. into *two equal* Solids, is ſimply as follows.

Take DR, *an arithmetical mean-proportional* between the two *Ordinates* AN, and BQ: that is to ſay, take the *Point* D, ſo that, the *hyperbolical Ordinate* DR, be equal to the *ſemi-ſum* of the two *Ordinates* AN, and BQ.

Or (which, from the nature of the Hyperbola, is the ſame thing), take the *hyperbolical Abſciſſe* CD, an *harmonical mean-proportional* between the two *abſciſſes* AC, and CB: that is to ſay, take the *Point* D, ſo that, the *whole Line* BC, be to *one extreme* Part CA; as the *other extreme* Part BD, is to the *middle* Part DA. For, it is a well known Propoſition, that the *reciprocals*, of Quantities which are in *arithmetical* progreſſion, will be in *harmonical* progreſſion.

§ 135. If the *Point* D be thus taken; then, if a *Plane* be drawn through that *Point* D (perpendicular to the Axis CB), the *hyperbolical Solid n* N Q *q* will thereby be divided, into two *equal hyperbolick Solids*, *n*NR*r*, and *r*RQ*q*; as required.

DEMONSTRATION.

§ 136. Let p denote the *Ratio*, of the circumference of a Circle, to its diameter; or (which is the ſame thing), the *Ratio*, of the *Area* of a Circle, to the *ſquare* of the Radius.

§ 137. Then, the Cylinder $vVNn$ (whoſe height is AC, and the Radius of whoſe Baſe is NA,) will evidently be equal to $p \times NA \times NA \times AC$.

The Cylinder $xXRr$ (whoſe height is DC, and the Radius of whoſe Baſe is RD,) will, in like manner, be equal to $p \times RD \times RD \times DC$.

And the Cylinder $yYQq$ (whoſe height is BC, and the Radius of whoſe Baſe is QB,) will alſo be equal to $p \times QB \times QB \times BC$.

§ 138. Now, from the nature of the Hyperbola; every *Rectangle*, under any abſciſſe, and its *correſponding* Ordinate, will be a *given Quantity:* which given Quantity, I will call cc.

Therefore, $NA \times AC = RD \times DC = QB \times BC = cc$.

§ 139. Conſequently, from what has been juſt ſtated (§ 137), it is evident, that;
The Cylinder $vVNn = p \times cc \times NA$.
The Cylinder $xXRr = p \times cc \times RD$.
And the Cylinder $yYQq = p \times cc \times QB$.

§ 140. Therefore, (dividing by the *common Quantity*, Pxcc ~~p×aa~~)

The Cylinders $vVNn$, $xXRr$, and $yYQq$, are exactly in the *ſame Ratio* to each other; as the Ordinates NA, RD, and QB, reſpectively.

§ 141. Now, (by conſtruction, § 134), $NA \cdot RD \therefore DR \cdot QB$.
Therefore,
The Cylinder $vVNn \cdot$ the Cylinder $xXRr \therefore$
$\therefore$ the Cylinder $xXRr \cdot$ the Cylinder $yYQq$.
That is to ſay,
The Cylinder $vVNn -$ the Cylinder $xXRr$
$=$ the Cylinder $xXRr -$ the Cylinder $yYQq$.

§ 142. It has been demonſtrated, by the famous *Torricelli*, and others; that every *infinite acute hyperbolick Solid*, is exactly *equal* to the *Cylinder*, whoſe *Baſe* is the ſame with that of the Solid, and whoſe *height* is equal to the Diſtance between that Baſe and the Center of the Hyperbola.

§ 143. Therefore,
The Cylinder $vVNn =$ the infinite acute hyperbolick Solid $nNZz$;
The Cylinder $xXRr =$ the infinite acute hyperbolick Solid $rRZz$;
And, the Cylinder $yYQq =$ the infinite acute hyperbolick Solid $qQZz$.

§ 144. Conſequently,
The Cylinder $vVNn -$ the Cylinder $xXRr$
$=$ the infinite acute hyperbolick Solid $nNZz$
$-$ the infinite acute hyperbolick Solid $rRZz$;
(that is to ſay,) $=$ the *finite hyperbolick Solid* $nNRr$.

And the Cylinder $xXRr$ – the Cylinder $yYQq$
= the infinite acute hyperbolick Solid $rRZz$
– the infinite acute hyperbolick Solid $qQZz$;
(that is to ſay,) = the *finite hyperbolick Solid* $rRQq$.

§ 145. But, it has been demonſtrated above (§ 141), that; The Cylinder $vVNn$ – the Cylinder $xXRr$
= the Cylinder $xXRr$ – the Cylinder $yYQq$.
Therefore, the *finite hyperbolick Solid* $nNRr$
= the *finite hyperbolick Solid* $rRQq$.

That is to ſay; that, the *Plane* drawn through the *Point* D, perpendicularly to the Axis CB, will divide the *finite hyperbolick Solid* $nNQq$, into *two equal* Parts. *Q^{d}. E^{t}. D^{m}.*

§ 146. It is therefore evident, from what has been ſaid above (§ 133 and § 134), *if the Denſity of the Electricity*, of electrical Atmoſpheres, be *inverſely as the ſquare of the Diſtance*; that the *neutral* or *unelectrified Point* D, (where, the two *contrary* Electricities, of the two Ends, of the inſu-lated trebly-electrified cylindrical † metallick Body AB, meet, and deſtroy each other;) will always be a *fourth Point* of an *harmonical* Diviſion, of the Line BAC; the other *three Points* C, A, and B, being given. Fig. 9.

§ 147. From this conſideration, of an *harmonical* Di-viſion, it is evident; that the *ultimate* poſition, of the *neutral*

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† N. B. The *curved Part* only, of the Surface of the ſaid Cylinder, being taken into conſideration.

neutral Point D, muſt be exactly *in the middle* between the Points A and B; ſuppoſing the electrified Body PC, to be removed to an *infinite Diſtance*.

That is to ſay, that the *neutral Point* D, can, in *no caſe*, be nearer to the *remote* End B, of the cylindrical Body AB, than *half the Diſtance* between A, and B: al--ways ſuppoſing, that the Body AB be electrified only with *its own Electricity*, as explained above (§ 99).

§ 148. It is likewiſe evident, from the above-mentioned conſideration, of an *harmonical* Diviſion; that, the *evaneſcent* poſition of the *neutral Point* D, muſt be at A.

That is to ſay, that the *neutral Point* D will come to be at A, in the caſe, of the End A (of the Body AB) coming *into contact* with the charged Body PC.

PART VI.

PART VI.

SECTION 149.

HAVING demonſtrated in what manner, the *neutral* or *unelectrified Point*, would be always accurately determined; if we ſhould admit the *Law* ſuppoſed above, *of the Denſity of the Electricity*, of electrical Atmoſpheres, being *inverſely as the ſquare of the Diſtance*: I ſhall now proceed to ſhew *(by means of Experiments, and an harmonical Diviſion,)* that this is, in fact, *the very Law, which does take place in nature.*

EXPERIMENT 15.

Fig. 9. § 150. I took the large tinfoil Prime-Conductor PC mentioned above (§ 76), and having inſulated the cylindrical braſs Conductor AB (uſed in my Experiment 5, § 77), that was *forty inches* long, including the *ſemi Spheres*, at its two Ends; I placed it, as is repreſented in the Figure, with one End directly pointing towards the Prime-Conductor.

§ 151. The Air being, that day, extremely dry; the *Diſtance*, at which, the Prime-Conductor PC could be made to *ſtrike*, upon a Ball of *four inches* diameter, was full *eighteen inches*.

The Prime-Conductor was, as uſual, electrified *in plus*.

§ 152. The Diſtance, between the *near* End A of the inſulated Body AB, and the Prime-Conductor PC, was *three feet.*

But, this Diſtance was often varied, as will be hereafter related.

§ 153. We have ſeen (§ 146), that, according to *my Theory*; the *Point* D, where the inſulated *trebly-electrified* cylindrical metallick Body AB was in its *natural* ſtate, (that is to ſay, the *Point* where the *two contrary* Electricities, of the two Ends of the Body AB, meet and counter-ballance each other;) would be the *fourth Point* of an *harmonical Diviſion*, of the Line CAB; the other *three Points* C, A, and B, being given: ſuppoſing the *Denſity of the Electricity*, of the ſuperinduced electrical Atmoſphere, to be *inverſely as the ſquare of the Diſtance.*

That is to ſay, that the *whole Line* BC, would be, to one of its *extreme* Parts CA; as the other *extreme Part* BD, is to the *middle Part* DA.

§ 154. Now, if BC : CA :: BD : DA.

Then,

BC+CA (*i.e.* BA+2AC) : CA :: BD+DA (*i. e.* BA) : AD.

That is to ſay, BA being equal to *forty* inches (§ 150), and CA being equal to *thirty-ſix* inches (§ 152); that,

$40+\overline{36\times2}$ (*i. e.* 112) : 36 :: 40 : AD.

Conſequently, $\mathrm{AD}=\frac{36\times40}{112}=12$ inches $\frac{6}{7}$.

§ 155. Having made a ſlight *Mark* [†], upon the ſide of the inſulated cylindrical metallick Body AB, at the Diſtance of 12 inches and $\frac{6}{7}$ from the *near* End A; *that Point* I called D.

§ 156. Having electrified the Prime-Conductor PC; I approached towards the *near* End A, of the inſulated Body AB, a ſmall electrometrical Ball, ſuſpended by a very fine thread of flax; and it appeared, as it had in Experiment 6 (§ 80), that the *near* End A was electrified *in minus*. The Prime-Conductor PC being *plus*.

§ 157. It alſo appeared, as it had in Experiment 7 (§ 81), that the *remote* End B, of the Body AB, was *poſitive*.

§ 158. When I moved the electrometrical Ball, gradually from the *near* End A, towards the *Point* D where I had made the *Mark* mentioned above (§ 155); the ſtrength of the *minus* Electricity of that Portion AB, of the Body AB, appeared gradually to decreaſe.

§ 159. In like manner, when I moved the electrometrical Ball, gradually from the *remote* End B, towards the ſame *Point* D; the ſtrength of the *plus* Electricity of that Portion BD, of the Body AB, appeared gradually to decreaſe.

§ 160.

[†] In order to render the *Mark* the more viſible, I generally ſtuck a ſmall piece of ſoft *wax* upon it.

§ 160. When I held the electrometrical Ball directly *oppoſite* to the *Point* D, where I had made the Mark above-mentioned; the Ball ſeemed to waver, but was neither *attracted*, nor *repelled*.

§ 161. From this it appears, that the Body AB, at the *Point* D (which was taken the *fourth* Point of an *harmonical* Diviſion, of the Line CAB; the other *three* Points C, A, and B, being given), was neither *plus*, nor *minus*. That is ſay, that the Body AB was *there*, in its *unelectrified* or *natural* ſtate; agreeably to the *Theory* above-laid down (§ 146).

§ 162. I repeated this Experiment ſeveral times; the Bodies AB and PC being placed, at various Diſtances (from *four inches*, to *four feet*) aſunder, as ſet down in the following TABLE (§ 168).

But, as the Electricity of the Prime-Conductor was ſo ſtrong, as to cauſe, that day, a *ſtriking Diſtance* of full *eighteen inches*, as I have ſaid above (§ 151); I was obliged, whenever the Diſtance AC was *leſs* than *two feet* or thereabouts, to give a *weaker* Charge to the Prime-Conductor PC. And when the Diſtance AC was diminiſhed to a ſtill greater Degree; I was obliged to diminiſh the Charge of the Prime-Conductor conſiderably.

EXPLANATION OF THE FOLLOWING TABLE.

§ 163. The *firſt* Column denotes the Diſtance CA, at which, I placed the inſulated Body AB, from the Prime Conductor; in each of the *twelve* Experiments ſet down in the TABLE.

§ 164. The *ſecond* Column ſhews, in what manner, the numbers, in the *third* Column of the TABLE, were determined according to my Theory of an *harmonical* Diviſion.

§ 165. The *third* Column denotes the Diſtance AD, at which, I made a Mark on the inſulated Body AB, when that Body AB and the Prime-Conductor PC were at the Diſtance expreſt, upon the ſame Line, in the *firſt* Column.

§ 166. The *fourth* Column ſhews the Proportion between the Diſtance DA, and the Diſtance AB, in each of the reſpective caſes ſet down in the *firſt* Column.

That is to ſay, that the *Numerator* of the Fraction expreſſes the Diſtance DA; the Diſtance AB being expreſt by the *Denominator* of the ſame Fraction.

§ 167. The *fifth* Column expreſſes the ſame Fractions (that are ſet down in the *fourth* Column) reduced to a *common Numerator*.

N. B. If the length AB (inſtead of being *forty* inches, as ſet down in the TABLE,) be *n* inches; and if the Diſtance CA, expreſt on any line in the *firſt* Column, be *proportionably* varied; then, the reſpective numbers, in the *third* Column, will be *proportionably* varied likewiſe.

SECTION

SECTION 168.

TABLE

Of the different DISTANCES, at which, the Experiment 15th was made, and of the reſpective RESULTS.

N. B. The length of the Body AB, is here always equal to *forty* inches, as was ſaid above (§ 150 and § 154). Fig. 9.

1. Column. Inches	2. Column.	3. Column. Inches	4. Column.	5. Column.
If CA= 4	then, AD=$\frac{4\times40}{48}$	$=3\frac{1}{3}$	$=\frac{1}{12}$ of AB	$=\frac{1}{12}$ of AB.
If CA= 8	then, AD=$\frac{8\times40}{56}$	$=5\frac{5}{7}$	$=\frac{2}{14}$ of AB	$=\frac{1}{7}$ of AB.
If CA=12	then, AD=$\frac{12\times40}{64}$	$=7\frac{1}{2}$	$=\frac{3}{16}$ of AB	$=\frac{1}{5\frac{1}{3}}$ of AB.
If CA=16	then, AD=$\frac{16\times40}{72}$	$=8\frac{8}{9}$	$=\frac{4}{18}$ of AB	$=\frac{1}{4\frac{1}{2}}$ of AB.
If CA=20	then, AD=$\frac{20\times40}{80}$	$=10$	$=\frac{5}{20}$ of AB	$=\frac{1}{4}$ of AB.
If CA=24	then, AD=$\frac{24\times40}{88}$	$=10\frac{10}{11}$	$=\frac{6}{22}$ of AB	$=\frac{1}{3\frac{2}{3}}$ of AB.
If CA=28	then, AD=$\frac{28\times40}{96}$	$=11\frac{2}{3}$	$=\frac{7}{24}$ of AB	$=\frac{1}{3\frac{3}{7}}$ of AB.
If CA=32	then, AD=$\frac{32\times40}{104}$	$=12\frac{4}{13}$	$=\frac{8}{26}$ of AB	$=\frac{1}{3\frac{1}{4}}$ of AB.
If CA=36	then, AD=$\frac{36\times40}{112}$	$=12\frac{6}{7}$	$=\frac{9}{28}$ of AB	$=\frac{1}{3\frac{1}{9}}$ of AB.
If CA=40	then, AD=$\frac{40\times40}{120}$	$=13\frac{1}{3}$	$=\frac{10}{30}$ of AB	$=\frac{1}{3}$ of AB.
If CA=44	then, AD=$\frac{44\times40}{128}$	$=13\frac{3}{4}$	$=\frac{11}{32}$ of AB	$=\frac{1}{2\frac{10}{11}}$ of AB.
If CA=48	then, AD=$\frac{48\times40}{136}$	$=14\frac{2}{17}$	$=\frac{12}{34}$ of AB	$=\frac{1}{2\frac{5}{6}}$ of AB.

§ 169.

§ 169. I repeated the Experiments, with the light electrometrical Ball ſeveral times, in *all* the different caſes ſtated in this TABLE, and in ſome *intermediate* caſes.

I alſo repeated a great number of Experiments ſimilar to theſe, with a *negative*, as well as with a *poſitive* Apparatus; as will be hereafter related.

§ 170. It was not always eaſy to aſcertain within an *hundredth*, or even within an *eigthtieth* Part, of the length Fig. 9. of AB; what was the exact *poſition* of the *neutral* or *un-electrified* Point: becauſe, at a *ſmall* Diſtance from that *Point*, the *plus* Electricity on the one ſide, and the *minus* Electricity on the other ſide, were extremely weak.

But, as near as I was able, in all my Experiments, to determine the poſition of that *neutral* Point; I found, that it did *correſpond* perfectly with the *Point* D, in the TABLE; as determined by the Theory.

§ 171. That is to ſay, that the *neutral Point* was always found to be the *fourth* Point of an *harmonical* Diviſion, of the Line CAB; the other *three* Points, C, A, and B, being given.

Fig. 9. § 172. We have ſeen above (§ 77 and § 150), that the Body AB, was a *Cylinder*, terminated at each End in a *ſemi-Sphere*.

If the Body AB, had been of a *cylindrical form throughout*; then, not only the Edges of the Baſe would, in a certain degree, have acted like *Points*, upon the electrical Atmoſphere ſuperinduced; but, the *ſurface of the Baſe*, at each End, would have prevented the *neutral Point* from being a *fourth* Point of the *harmonical* Diviſion mentioned above (§ 171), ſince, the property of an *harmonical* Diviſion does depend, in a *Cylinder* (for example), upon the *curve Part of the Surface* of the Cylinder, (excluſive of either *Baſe)* being acted upon by the electrical Fluid, of the *electrical Atmoſphere*, in which that inſulated Cylinder is immerged.

§ 173. Now, it is a well-known Propoſition, if there be (a *Sphere*, or) a *ſemi-Sphere* FLE, inſcribed within an *upright Cylinder* EFGH; that, the whole *curve Surface of the Cylinder*, will be exactly *equal* to the whole *curve Surface of the ſemi-Sphere*. The former Quantity being *equal* to *twice the Area* of the Baſe of a Cylinder, whoſe Diameter is EF; and the latter Quantity being *equal to twice the Area* of a great Circle of a Sphere, whoſe Diameter is alſo EF. Fig. 12.

§ 174. It is likewiſe a well-known Propoſition (of which the Propoſition juſt-mentioned, is only a particular caſe), that, if an *upright Cylinder* EFGH, and (the *Sphere*, or) the *ſemi-Sphere* FLE, inſcribed therein, be cut by *any two Planes* whatever KM and *km*, which are both parallel to the Baſe of the Cylinder; then, *the Part of the curve Surface* of the Cylinder, which is contained between theſe two parallel Planes KM and *km*, will always be exactly *equal* to *that Part of the Surface* of the (inſcribed *Sphere*, or) inſcribed *ſemi-Sphere*, which is contained between the *ſame* two parallel Planes KM and *km*.

§ 175. Therefore, in the *cylindrical* Body AB, mentioned above (§ 77 and § 172), which was *forty inches* long, including the *ſemi-Spheres* at its two Ends; it is evident, Fig. 9.

1ſt. That the *whole Quantity of electrical Fluid*, of any electrical Atmoſphere, *ſuperinduced* upon the *whole Surface* of that Body AB; would be exactly *equal* to the *whole Quantity of electrical Fluid*, of the ſame electrical Atmoſphere, *ſuperinduced* upon the *whole curve Part of the Surface* of a Cylinder of *forty inches* long, of an equal Diameter with the Body AB (and ſimilarly ſituated with reſpect to the charged Prime-Conductor PC), but, which was terminated at each End, in a *flat Baſe*, inſtead of *a ſemi-Sphere*.

And 2dly, That the *whole Quantity of electrical Fluid*, of the electrical Atmoſphere, *ſuperinduced* upon the *Surface* of the ſaid Body AB, at *any given Diſtance* from the charged Body PC; would be exactly *equal* to the *whole Quantity of electrical Fluid*, of the ſame electrical Atmoſphere, *ſuperinduced*, at the *ſame given Diſtance* from the charged Body PC, upon the *curve Part of the Surface* of the above-mentioned Cylinder of *forty inches* long, terminated at each End, in a *flat Baſe*, inſtead of a *ſemi-Sphere*.

§ 176. It therefore, moſt evidently follows, from what has been ſaid above (§ 131, § 146, § 174 and § 175),

1ſt, That, according to my Theory, the *neutral* or *un-electrified Point*, of the cylindrical Body AB mentioned above (§ 77 and § 175), which Body was terminated at each End in a *ſemi-Sphere*; muſt be a *fourth* Point of an *harmonical* Diviſion of the Line CAB; the other *three* Points C, A, and B, being given: ſuppoſing the *electrical Denſity of electrical Atmoſpheres to be in the inverſe Ratio of the ſquare of the Diſtance*. Fig. 9.

And 2dly, That, according to my Theory, the *neutral* or *unelectrified Point*, of any *Sphere*[†], immerged in the electrical Atmoſphere of a charged Body; muſt likewiſe (in a manner exactly ſimilar), be a *fourth* Point of an *harmonical* Diviſion: ſuppoſing the *electrical Denſity of electrical Atmoſpheres to be in the inverſe Ratio of the ſquare of the Diſtance.*

Fig. 9.

§ 177. Now, we have ſeen, that the *neutral* or *unelectrified Point*, of the Body AB mentioned above (§ 77 and § 176) which Body was terminated at each End, in a *ſemi-Sphere*; was always found to be, in all the *Experiments* related above (from § 150 to § 171), a *fourth* Point of an *harmonical* Diviſion; the other *three* Points C, A, and B, being given.

That is to ſay, that the Diſtance, between the *neutral Point* D, and the *near* End A (of the inſulated Body AB); was to the Diſtance, between the *neutral Point* D, and the *remote* End B; always in the *ſame ratio*, as the Diſtance, between the *charged Body* PC, and the ſame *near* End A; to the Diſtance between the *charged Body* PC, and the ſame *remote* End B.

§ 178. Conſequently, it evidently appears, from what was ſaid above (§ 146 and 177), *that the Denſity*[††] *of the Electricity; of the electrical Atmoſphere* (in which the ſaid Body AB was immerged) *was in the inverſe Ratio of the ſquare of the Diſtance.*

[†] There are alſo a few other *Solids*, of a particular form, in which, the *ſame* property of an electrical *harmonical* Diviſion will be found.

[††] This Demonſtration, I am ſenſible, would have been more mathematically accurate, had I taken the *Converſe* of the Propoſition ſtated above, in § 146: but, the *Converſe* of Propoſitions of *this kind*, may very well be diſpenſed with, in certain Caſes; of which, *this* is one.

PART VII.

SECTION 179.

IT is indiſpenſably neceſſary to perform this laſt ſet of Experiments with particular attention, or the *reſults* will *not* agree with thoſe I have given in the foregoing TABLE (§ 168).

§ 180. If, (for example) any inſulated unelectrified conducting Body, of a ſmall, or of a moderate Size, be brought *into contact* with the *near* End A, of the Body AB, whilſt that Body AB is in a ſtate of *three-fold* Electricity; it will communicate a certain Part of its Electricity, to that Body AB; in order, to ſupply ſome of the *deficient* Electricity, of the *negative* Portion AD, of that Body. Fig. 9.

Therefore, the inſulated conducting Body will, by loſing a Part of its *natural* ſhare of Electricity, become *negative*. And the Body AB will, of conſequence, become *poſitive*.

§ 181. If any inſulated unelectrified *conducting Body* be brought *into contact* with the *remote* End B, of the Body AB, whilſt that Body AB is in a ſtate of *three-fold*

Electricity; the *poſitive* Portion DB, of that Body AB, will depoſit thereon, a certain Part of its *ſuperabundant* Electricity.

Therefore, the inſulated conducting Body will become *poſitive*. And the Body AB will, of conſequence, become *negative*.

§ 182. If the Body AB, whilſt it is in a ſtate of *threefold* Electricity, be made, by any means, to *communicate with the Earth*: then, the Body AB and the *common Stock* will make, as it were, but *one Body*; whether the conducting Body, which is made uſe of to form that Communication, be brought into contact with the *near* End, or with the *remote* End, of that Body AB.

Conſequently, the *ſuperinduced elaſtick electrical Preſſure*, of the Prime-Conductor's electrical *Atmoſphere*, will cauſe a certain Portion of the *natural* ſhare of Electricity, contained in the Body AB, to paſs into the *common Stock*. Therefore, the Body AB, will become *negative*.

§ 183. It is therefore, evident from this; if the Body AB be ſupported by *imperfect Conductors*, that it muſt become *negative*, as ſoon as it becomes affected by the *ſuperinduced elaſtick electrical Preſſure* of an electrical Atmoſphere.

§ 184. From the ſame conſideration, it is moreover evident; that, if the *Air* round the Body AB *be damp*, ſo as to become a Conductor of Electricity; the Body AB will become *negative*, as ſoon as it becomes affected by the *ſuperinduced elaſtick electrical Preſſure* of the electrical Atmoſphere.

This Effect is more conſiderable, than moſt Perſons would be apt to imagine.

§ 185. One day (for inſtance) when the Air was *damp*; I attempted to repeat my *fifteenth Experiment* †, with Fig. 9. the cylindrical Body AB, at almoſt all the *Diſtances* from the Prime-Conductor PC, that are mentioned in the *firſt* Column of the foregoing TABLE (§ 168): and, to my great aſtoniſhment at the moment, I found that the *neutral* or *unelectrified* Point D (inſtead of being, as in the *third* Column of the TABLE, a *fourth* Point of an *harmonical* Diviſion of the Line CAB; the other *three* Points C, A, and B, being given,) was *always* nearly at the Diſtance of *ſixteen inches*, from the *near* End A, of the Body AB; whatever were the Diſtance, between A and C.

§ 186. Upon examination, I ſoon diſcovered that the Body AB always *loſt* Electricity, during the Experiment; and that the *nearer* the Body AB was brought to the *plus* electrified Prime-Conductor, the *more Electricity* that Body AB loſt. That is to ſay, the more that Body became *negative*. The conſequence of which was, that the length of the *negative* Portion AD, of the cylindrical Body AB, was increaſed; and that the length of the *poſitive* Portion DB, was decreaſed. That is to ſay, that the *neutral* or *unelectrified* Point D, came to be *nearer*

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† See § 150, & ſeq.

nearer to the *remote* End B, of the Body AB, than it would otherwiſe have been.

It was perfectly evident, that the *dampneſs of the Air* was the Cauſe of this Effect.

§ 187. Again; the Body AB will be rendered *negative*, ſhould there be, within the *ſenſible* Part of the *electrical Atmoſphere*, of that Body (whilſt it is in a ſtate of *three-fold* Electricity) any *pointed* conducting Body, which communicates with the Earth; whether, the Point be placed near to the *near* End, or near to the *remote* End, or near to any *other* Part, of the Body AB.

§ 188. The reaſon of this, is; that the *Point*, by being connected with the Earth, tends, in a certain Degree, to form a kind of *Communication*, between the Body AB and the *common Stock*; for the reaſons explained above.

§ 189. If there be, any kind of *Points*, on the inſulated Body AB, whilſt it is in a ſtate of *three-fold* Electricity; they alſo will entirely diſturb the Experiment, for the following reaſons.

§ 190. A ſharp metallick Point, fixt to the *negative near* End A, of the Body AB, will *receive* Electricity. Therefore, the Body AB will become *poſitive*.

§ 191. If, on the contrary, a very prominent and acute metallick Point be fixt to the *remote* End B, which is *poſitive*; it will *tranſmit* Electricity to the circumambient Air. Therefore, the Body AB will become *negative*.

§ 192. For this laſt-mentioned Effect to be ſtrong, the Electricity of the Prime-Conductor muſt be conſiderable, and the Body AB muſt *not* be very much beyond the *ſtriking Diſtance* of the Prime-Conductor. A very *delicate Electrometer* (ſuch a one, for example, as that deſcribed in the *Note* to § 10), ſhould be made uſe of, to aſcertain correctly the *Quality* of the Electricity.

This is an Experiment which requires to be made with particular care.

§ 193. If, in my 15th Experiment †, the *Diſtance*, between the inſulated Body AB and the electrified Prime Conductor PC, be but *very little* more than the *ſtriking Diſtance* of the Prime-Conductor; it will often happen (if the Electricity be ſtrong), that the ſuperinduced elaſtick electrical *Preſſure*, of the Prime-Conductor's electrical Atmoſphere, will be able, in a certain Degree, to overcome the *Reſiſtance*, oppoſed, at the Surface of the Body AB, to the Entrance of that electrical Atmoſphere's *plus* Electricity.

This will therefore cauſe the Body AB to become *poſitive*.

§ 194. The Body AB, therefore, ought *not* (generally ſpeaking,) to be *nearer* to the Prime-Conductor, than about five ~~three~~ *quarters* of the *ſtriking Diſtance* of the Prime Conductor, upon any large metal Ball that is properly connected with the common Stock.

§ 195. I think it muſt appear ſufficiently evident, from what has been here ſaid; that very favourable wea-

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† § 150 & ſeq.

-ther, and many attentions are neceſſary, for thoſe Experiments which are given in the TABLE †, (or for any other Experiments ſimilar in principle) to ſucceed properly.

§ 196. But, I may lay it down as one *general Rule*, that, in order for *any ſuch* Experiments to ſucceed, it is always indiſpenſably neceſſary; that, the Body AB (whilſt it is in a ſtate of *three-fold* Electricity) ſhould neither *loſe* any Part of its *own* electrical Fluid, nor *acquire* any more than its *natural* ſhare of Electricity.

§ 197. With inſulated, metallick Bodies of different lengths, and of different ſizes, placed at different Diſtances, from Prime-Conductors of different ſizes, and charged with different Degrees of Electricity; I have often repeated Experiments, ſimilar to thoſe above deſcribed. And, when the weather was very favourable, and the Experiments were made with due care; I always found, that the *reſults* of ſuch Experiments did correſpond perfectly, with the *Theory* I have above laid down.

§ 198. The ſame thing happened, when I repeated the Experiments with a *negative*, inſtead of a *poſitive* Apparatus. But, when the *negative* Apparatus was made uſe of; all the *Parts* of the inſulated Body AB, that had been *poſitive* before, became *negative*; and all the *Parts*, that had been *negative* before, became *poſitive*; as muſt neceſſarily be the caſe.

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† § 168.

The *neutral* or *unelectrified Point* was always found to be a *fourth* Point of the *harmonical* Diviſion of the Line CAB; the other *three* Points C, A, and B, being given. But, as my *negative* Apparatus, was conſiderably weaker than the *poſitive* Apparatus mentioned above (§ 150 and § 151), I could not pretend to determine the *neutral Point*, with quite as much preciſion, as when I made uſe of that *poſitive* Apparatus.

§ 199. The great uſe that there is, in determining the *Law*, according to which, the *Denſity of the Electricity* of electrical Atmoſpheres decreaſes, muſt appear evident to all thoſe who are able to form the moſt diſtant idea of the *important conſequences* which may be drawn from it, in the further inveſtigation of Electricity.

§ 200. I propoſe, in ſome future work, to point out ſome of thoſe *important conſequences*; and to explain the reaſon, why the *Denſity of the Electricity*, of an electrical Atmoſphere, *ſuperinduced* upon any Body, muſt be *inverſely as the ſquare of the Diſtance* from the charged Body producing that electrical Atmoſphere.

§ 201. In the mean time, it may be ſufficient to take notice; that *this is the Law*, according to which the *ſtrength of Heat* decreaſes; according to which, the *denſity of the Rays of Light*, decreaſes; and according to which, the *univerſal force of Gravity* decreaſes alſo.

And it was by an attentive conſideration of certain Parts, of that very ingenious *Syſtem of Gravitation* †, invented by that excellent Man and moſt reſpectable Philoſopher Mr. *le Sage* (of *Geneva*) F. R. S. &c. that I was inſenſibly led to diſcover the new and concluſive Demonſtration which I have given, in the foregoing pages, that *this Law* does hold alſo *in Electricity*.

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† After having been lead, by Mr. *le Sage's Syſtem of Gravitation* here alluded-to, and by *my Theory of Electricity* above-explained, to diſcover the property of an *harmonical* Diviſion, as before-mentioned; I was naturally led to diſcover from thence, that a *ſimilar* Propoſition of an *harmonical Diviſion* is true alſo with reſpect to *Gravity*; if the *Center of Gravity* of a Body, *in Staticks,* be ſubſtituted inſtead of the *neutral* or *unelectrified Point*, of an inſulated conducting Body, *in Electricity*; and if the *Quantity of Matter* of the Body, whoſe *Center of Gravity* is ſought, be ſubſtituted inſtead of the *Surface* of the *trebly-electrified* Body, whoſe *neutral* or *unelectrified Point* is required. The *weight* of a Body, being as the *Quantity of Matter* therein contained: whereas, the Quantity of *plus*, or the Quantity of *minus* Electricity, contained in a Body that is *electrically charged*, is well known to reſide only on the *Surface* of the Body which is ſo electrified.

That is to ſay, if an upright *Cylinder*, an upright *Priſm*, or any upright *Solid* whatever (which has a right Line for its *Axis*, which has its *Baſes* equal and parallel, and which is of an equal *Size* and of an equal *Denſity* from one End to the other), be ſo placed, as to have its *Axis* directly pointing towards the *Center of Attraction* of the Earth; that then, the Center of Gravity, of the ſaid *Cylinder*, *Priſm*, or other *Solid*, will *not* be (as is generally imagined), in the *middle* of the length of the Solid; but, that it will always be, a *fourth* Point of an *harmonical* Diviſion; the *upper End* of the Solid, the *lower End* of the Solid, and the *Center of Attraction* of the Earth, being the other *three* given Points. Let this be compared to what was ſaid above, § 146.

But, as the *Center of Attraction* of the Earth, is at an *immenſe Diſtance*, when compared to the *length* of any of the movable Bodies upon the Surface of the Earth; it is evident, that the *Center of Gravity* of the Solid, will be *ſenſibly* (tho' not *mathematically*) in the *middle* of the length of the Solid. Let this be compared to what was ſaid above, § 147.

A ſimilar kind of Propoſition to that mentioned before (in this *Note*), of an *harmonical* Diviſion, will take place, even in *oblique* Cylinders, and in *oblique* Priſms, &c. provided that their *Baſes* be parallel to the horizon.

If the elaſtick electrical *Preſſure*, of any ſuperinduced *electrical Atmoſphere*, were *equally* great, at *all Diſtances* from the charged Body producing that *electrical Atmoſphere*; then, the *neutral* or *unelectrified Point*, in the Bodies mentioned above in § 176, would be always exactly in the *middle* of thoſe Bodies.

The reaſon, why the *neutral* or *unelectrified* Point (in the caſes above-ſtated) is a *fourth* Point of an *harmonical* Diviſion, is, becauſe the *Denſity of the Electricity*, of electrical Atmoſpheres, is in the *inverſe Ratio of the ſquare of the Diſtance*; as I have already ſufficiently explained.

In like manner, if the *Force of Gravity* were *equally* great, at *all Diſtances* from the *Center of Attraction* of the Earth; then, the *Center of Gravity*, in the upright *Cylinder*, in the upright *Priſm*, or in the other upright *Solid* (mentioned before in this *Note*), would always be exactly and mathematically, in the *middle* of thoſe Bodies. And the reaſon, why the *Center of Gravity* (in the caſes juſt-mentioned) is a *fourth* Point of an *harmonical* Diviſion, is, becauſe the *Force of Gravity* is in the *inverſe Ratio of the ſquare of the Diſtance*.

It therefore appears evident, that *mathematically* (tho' not *mechanically*) ſpeaking, *no Body*, of any ſize, or of any ſhape whatever, either can have its *Center of Gravity*, in *any* caſe, in the Center of the *Quantity of Matter* it contains; or can have, under any circumſtances, any *permanent Center of Gravity* whatſoever.

So that, mathematically and correctly ſpeaking, the *common Definition* of the *Center of Gravity* of a Body (viz. “ *that Point*, upon which, if the Body be ſuſpended, in *any* poſition whatever, it will always remain in perfect *æquilibrio*”) is a compleat abſurdity, and no leſs than a *direct contradiction* in terms.

* * *

PART VIII.

PART VIII.

SECTION 202.

HAVING laid down, in the fulleſt manner, the *Theory* of what happens *to a ſingle conducting Body*, which is immerged in an *electrical Atmoſphere*, but which is, at the ſame time, out of the *ſtriking Diſtance* of the charged Body that produces that electrical Atmoſphere; I will now examine what muſt happen, when there are *two* or *more* Bodies, in ſomewhat a ſimilar ſituation.

§ 203. We have already ſeen (from § 180 to § 183), what muſt follow, from a *ſingle inſulated conducting Body* (whilſt it is in a ſtate of *three-fold* Electricity), having another *inſulated conducting Body* brought *into contact* with it; or, from its being made to communicate, with the *common Stock*.

The following Experiments will ſhew, in what manner, *remarkable Effects* may be produced, by *conducting Bodies*, under certain circumſtances, being placed, even in an *inſulated* ſituation, within an electrical Atmoſphere, at *ſmall Diſtances* from each other.

EXPERIMENT 16.

§ 204. I made uſe, in the following ſet of Experiments, of the ſame Prime-Conductor, which I mentioned above (§ 76 and § 150).

Fig. 13. I placed an inſulated metallick Body AB, within the electrical Atmoſphere, of the Prime-Conductor PC, when charged; but out of *the ſtriking Diſtance*. The Diſtance, between the *near* End A, of the inſulated metallick Body AB, and the ſide of the Prime-Conductor PC, was *twenty inches*.

The Body AB was of braſs, of a cylindrical form, and terminated at each End by a ſmooth *three-quarter Ball*, as repreſented in the Figure. The cylindrical Part of the Body AB, was eighteen inches long, by two inches diameter. The diameter of the Balls A and B, was about two inches and three eighths.

§ 205. I then placed another inſulated cylindrical braſs Body EF (forty inches long, by about three inches and three quarters diameter), with its End E, at the Diſtance of about *one tenth* of an inch, from the End B, of the other metallick Body AB.

§ 206. We have ſeen above (§ 72 and § 73), when any inſulated conducting Body (ſuch as the Body AB, in this inſtance) be placed, within the *electrical Atmoſphere* of any charged Body (ſuch as PC,) but out of the *ſtriking Diſtance*; that then, the *near* End A, of this Body AB, will be electrified, in a manner *contrary* to that of the

Prime-Conductor; that, the *remote* End B will be electrified, in the *ſame* manner as the Prime-Conductor; and that, a certain Point D, will be *not electrified at all.*

That is to ſay, that, in this caſe, the *near* End A, of the Body AB, will be *negative*; and the *remote* End B will be *poſitive*. Therefore, the *plus* Electricity, of the *remote* End B, will tend to *run out* of the Body AB, whenever it ſhall find any *conducting Body*, that is ſo ſituated, as to be able to *receive* it.

§ 207. The three Bodies PC, AB and EF, being placed, with reſpect to each other, in the ſituation juſt deſcribed (§ 204, § 205 and § 206), I electrified the Prime Conductor PC. Fig. 13.

All the time, that the Prime-Conductor was receiving its *plus* Charge of Electricity; there paſſed a great number of *weak* (red or purple) *ſparks*, from the End B of the *near* Body AB, into the End E of the *remote* Body EF.

Sometimes, the Electricity paſſed, from B to E, in a *white ſtream.*

§ 208. When the Prime-Conductor PC, having received its full charge, came ſuddenly to diſcharge, with an *Exploſion*, its *ſuperabundant* Electricity, upon the large braſs Ball L, which was made to communicate with the Earth: it always happened, that the electrical Fluid, which had been gradually *expelled*, from the Body AB, and driven into the Body EF (by the ſuperinduced elaſtick electrical *Preſſure*, of the electrical Atmoſphere, of the Prime Conductor PC, whilſt it was charging), did *ſuddenly re-*

-*turn*, from the Body EF, into the Body AB, in a ſtrong *bright ſpark*; at the very inſtant, that the *Exploſion took place* upon the Ball L.

This I call the electrical *returning Stroke*.

EXPERIMENT 17.

§ 209. The Bodies AB and EF, and alſo the Prime Conductor PC, being placed in the ſame ſituation, as they were in the laſt Experiment; I electrified the Prime-Conductor: upon which, there paſſed a great number of weak *ſparks*, from the Body AB, to the Body EF; as in the former Experiment. I then ſuddenly approached, Fig. 13. towards the Prime-Conductor PC, an uninſulated metallick *Point* W; which, by ſilently carrying off the Electricity of the Prime-Conductor, did remove from the inſulated Body AB, the ſuperinduced elaſtick electrical *Preſſure*, of the Prime-Conductor's electrical Atmoſphere.

The conſequence of which was, that the electrical Fluid, which had been expelled from the Body AB into the Body EF, did *return* from the Body EF into the Body AB, in a *ſwift ſucceſſion* of electrical ſparks, or in a *white ſtream*.

This is a clear illuſtration of the laſt Experiment.

EXPERI-

EXPERIMENT 18.

§ 210. If, at any time, when the Prime-Conductor PC was almoſt charged; I removed the *near* Body AB (in its *inſulated* ſtate), quite out of the *electrical Atmoſphere* of the Prime-Conductor; I invariably found, by means of an Electrometer, that the Body AB was electrified *in minus*. That is to ſay, that it was charged with a *contrary* Electricity, to that of the Prime-Conductor; agreeably to the Theory above laid down.

EXPERIMENT 19.

§ 211. If, when the Prime-Conductor PC was almoſt charged, I, on the contrary, removed the *remote* Body EF (in its *inſulated* ſtate), quite out of the *electrical Atmoſphere* the Prime-Conductor; I invariably found, that the Body EF was electrified *in plus*. That is to ſay, that it was charged with the *ſame* kind of Electricity, as that of the Prime-Conductor; agreeably to the *Theory* above laid down.

EXPERIMENT 20.

§ 212. Having entirely removed the Bodies AB and EF; I placed, within the electrical *Atmoſphere* of the Prime-Conductor PC, and at about *one thirtieth* Part of an inch aſunder, two inſulated ſmooth braſs Balls G and H; each of which was of about *two inches* diameter.

The Diſtance of the *near* Ball G, from the Prime-Conductor PC, was *twenty inches*: that is to ſay, at the *ſame* Diſtance from it, as the *near* End A, of the Body AB, in my 16th Experiment †.

§ 213. Whilſt the Prime-Conductor PC was charging; I could not perceive any ſpark, between the two Balls G and H; the Quantity of Electricity which paſſed, being ſo very ſmall.

§ 214. But, at the *inſtant of the Diſcharge* of the Prime Conductor, upon the Ball L; there conſtantly appeared a ſmall *ſpark* between the Balls G and H.

§ 215. This *ſpark* (which was ſo much ſhorter than that, in my 16th Experiment) was evidently occaſioned by the *ſudden return* of the electrical Fluid, which (from the *great proximity* of the Bodies G, and H, and from the *ſmall Quantity* of Electricity contained in them,) had paſſed from the Body G to the Body H, *not* in a ſucceſſion of *weak ſparks*, or in a white *ſtream*; but, in an inviſible electrical *ſilent Diſcharge*.

EXPERIMENT 21.

§ 216. Having entirely removed the two metal Balls G and H; I placed an inſulated metallick Body IK (ſimilar to the Body AB mentioned above in § 204) with its near End I, at the Diſtance of *twenty inches* from the ſide of the Prime-Conductor PC.

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† § 204. & ſeq.

I then fixt a ſharp Point MN, of about one inch and three quarters long, into the End N of another inſulated braſs Body NN (that was forty inches long, by about three inches and three quarters diameter), and I placed the Body NN in ſuch a manner, that the *Point* M ſhould be at the Diſtance of about *three tenths* of an inch, from the blunt End K of the other Body IK.

§ 217. Whilſt the Prime-Conductor PC was receiving its Charge of Electricity; much electrical Fluid paſſed, out of the End K of the inſulated Body IK, into the other Body NN: and as the Point M oppoſed but *a ſmall Degree of Reſiſtance*, to the Entrance of the electrical Matter into the Body NN, with which that Point M was connected; the Electricity did not paſs in a ſucceſſion of *weak ſparks* or in a white *ſtream*, from the Body IK to the Body NN, but in an electrical *ſilent Diſcharge* which was not viſible except upon the Point M.

§ 218. Now, when the Prime-Conductor PC had received its full charge of Electricity, and came ſuddenly to diſcharge, with an *Exploſion*, its *ſuperabundant* Electricity upon the Ball L which communicated with the common Stock; it invariably happened, as I had expected and foretold, that the electrical Fluid, which had been gradually expelled from the Body IK, and which had been driven into the Body NN (by the ſuperinduced elaſtick electrical Preſſure, of the *electrical Atmoſphere*, of the Prime-Conductor whilſt it was charging) did *ſud-*

-*denly return* from the Body NN into the Body IK, in a ſtrong bright *ſpark*, which iſſued from the Point M at the very *inſtant* that the *Exploſion* took place upon the Ball L.

§ 219. The reaſon why the *returning ſpark* (which paſſed from the *remote* Body, to the *near* Body) was about *three* times as long in this caſe, as it was when *no ſharp point* was fixt to the *remote* Body, is ſimply this.

§ 220. We have ſeen above (§ 34, § 35 and § 36), if an *acute prominent metallick Point* be fixt to a *poſitive* Body, that the *ſuperabundant* Electricity of that Body will be able to *run out* through the *prominent Point*, with a much greater Degree of *facility*, than it would through any *non-prominent* Point whatever of that Body.

Conſequently, if ſuch a *poſitive* Body was obliged, by any cauſe, to diſcharge *on a ſudden*, its ſuperabundant Electricity; it is evident, that the *ſpark* occaſioned by ſuch *an inſtantaneous Diſcharge*, muſt be able to fly to the *greateſt Diſtance*, in that caſe, in which, the *Electricity* conſtituting the *ſpark* meets with the *leaſt Reſiſtance*.

§ 221. The neceſſary *ſuddenneſs of the returning Stroke*, was the reaſon, and the only reaſon, of there being *any ſpark from the metallick Point*.

EXPE-

EXPERIMENT 22.

§ 222. I then placed the Body NN, at ſomewhat a greater Diſtance from the Body IK, than in the laſt Experiment; ſo that, when the *ſudden Diſcharge* of the Prime-Conductor PC came to take place upon the Ball L, the Body IK ſhould be out of the *Diſtance*, at which, the *returning Fluid* of the Body NN, would be able to paſs in an electrical *ſpark*, from the Body NN to the Body IK, through the Point M.

§ 223. In this caſe, the *inſtant* the Prime-Conductor PC did diſcharge, with an Exploſion, its *ſuperabundant* Electricity, upon the Ball L; the electrical Fluid, which had been expelled from the Body IK into the Body NN, did *return* from the Body NN, to the Body IK, in a fine *diverging electrical Bruſh* which iſſued from the Point M.

This *Bruſh* alone was a ſufficient proof, that, upon the *ſudden Diſcharge* of the Prime-Conductor taking place, the electrical Fluid did paſs *from* the Point M *to* the Body IK, and *not from* the Body IK *to* the Point M.

EXPERIMENT 23.

§ 224. Every thing being placed exactly in the ſame ſituation as in the laſt Experiment, I darkened the room, and I obſerved, that, whilſt the Prime-Conductor PC was receiving its Charge of Electricity, there appeared an electrical *Star* upon the Point M; which was a proof that the Body NN was *acquiring* Electricity.

§ 225. I then ſuddenly approached, towards the Fig. 13. electrified Prime-Conductor PC, an uninſulated Point W, as I had done in my 17th † Experiment; upon which, the *Star* at the Point M, was inſtantly converted into a narrow electrical *Bruſh*, that ſhot out from that metallick Point.

This Experiment does not leave the ſhadow of a doubt, what the *Direction* of the electrical Fluid was.

EXPERIMENT 24.

§ 226. I then took the needle out of the *remote* inſulated Body, and I fixt it into the *remote End* of the *near* inſulated Body; as is repreſented, by QQO and Fig. 13. RR, in the Figure.

The Diſtance, between the *Point* O and the *remote* Body RR, was about *three tenths* of an inch.

Whilſt the Prime-Conductor PC was receiving its Charge of Electricity, much electrical Fluid paſſed from the near Body QQ into the remote Body RR, in an electrical *ſilent Diſcharge*, which was not viſible except upon the Point O.

§ 227. As ſoon as the Prime-Conductor came to diſcharge, with an Exploſion, its *ſuperabundant* Electricity upon the Ball L; the electrical Fluid, which had been expelled, from the Body QQ into the Body RR, did *ſuddenly return* from the Body RR into the Body QQ, in a ſtrong bright *ſpark*, which flew to the Point O, at the very *inſtant* that the *Exploſion* took place upon the Ball L.

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† § 209.

§ 228. The reaſon, why the *returning ſpark* (which paſſed, from the *remote* Body, to the *near* Body) was about *three* times as long, in this caſe, as it was, when *no ſharp Point* was fixt, either to the *remote* Body or to the *near* Body, is ſimply this.

§ 229. We have ſeen above (§ 42, § 43 and § 44), if an *acute prominent metallick Point* be fixt to a *negative* Body, that the *deficient* electricity of that Body will be able to be ſupplied through the *prominent Point*, with a much greater degree of *facility*, than it would through any *non-prominent* Point whatever of that Body.

Conſequently, if ſuch a *negative* Body was obliged by any cauſe, to have its *deficient* Electricity ſupplied *on a ſudden*, it is evident that the *ſpark*, occaſioned by ſuch an *inſtantaneous Diſcharge*, muſt be able to fly to the *greateſt* Diſtance, in that caſe, in which, the *Electricity* conſtituting the *ſpark*, meets with the *leaſt Reſiſtance*.

§ 230. The *neceſſary ſuddenneſs* of the *returning Stroke*, was the reaſon, and the only reaſon, of *any ſpark flying*, *to the metallick Point*.

EXPERIMENT 25.

§ 231. I then placed the Body RR, at ſomewhat a greater Diſtance from the Body QQ, than in the laſt Experiment; ſo that, when the *ſudden Diſcharge* of the

Prime-Conductor PC came to take place, upon the Ball L; the Body QQ ſhould be out of the *Diſtance*, at which, the *returning Fluid* of the Body NN, would be able to paſs in an *electrical ſpark*, from the Body RR to the Body QQ.

§ 232. In this caſe, the *inſtant* the Prime-Conductor PC did diſcharge, with an Exploſion, its *ſuperabundant* Electricity, upon the Ball L; the electrical Fluid, which had been expelled from the Body QQ into the Body RR, did *return* from the Body RR into the Body QQ, and did appear in a bright electrical *Star*, upon the Point O.

EXPERIMENT 26.

§ 233. Every thing being placed exactly in the ſame ſituation as in the laſt Experiment, I darkened the room; and I obſerved, that, whilſt the Prime-Conductor PC was receiving its charge of Electricity, there appeared a narrow electrical *Bruſh*, upon the Point O; which was a proof, that the Body QQ was *loſing* Electricity.

§ 234. I then ſuddenly approched towards the electrified Prime-Conductor PC, an uninſulated Point W, as I Fig. 13. had done in my † 17h and †† 23rd Experiments; upon which, the narrow *Bruſh* at the Point O, was inſtantly converted into a *Star*, which appeared upon that metallick Point.

EXPE-

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† § 209. †† § 224 & § 225.

EXPERIMENT 27.

§ 235. I then fixed a ſharp Point (of about one inch and three quarters long) into the *near* End, of that inſulated Body which was the moſt *remote* from the Prime-Conductor PC. So that, there were, in this caſe, *two ſharp Points* (repreſented by ST and VX, in the Figure) directly pointing towards each other. The Diſtance between them was about *four tenths* of an inch. Fig. 13.

§ 236. Whilſt the Prime-Conductor PC was receiving its Charge of Electricity, there paſſed much electrical Fluid, in a *ſilent Diſcharge*, from the inſulated Body SS, into the inſulated Body XX, through the two ſharp Points T and V.

§ 237. Now, when the Diſcharge of the Prime Conductor PC, came to take place upon the Ball L; then, the *ſuperabundant* Electricity, which the Body XX had received from the Body SS, did *ſuddenly return* from the Body XX into the Body SS, in a ſtrong bright *Spark*, which paſſed between the two ſharp Points V and T, at the very *inſtant* that the Exploſion took place upon the Ball L.

§ 238. The reaſon, why the *returning ſpark* (which paſſed from the *remote* Body to the *near* Body) was *longer* in this caſe, than it had been, either in the † 21ſt or in the 24th † Experiments, when *one Point* only was made uſe of, is ſimply this.

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† § 216 & ſeq.

§ 239. We have ſeen above (§ 220), if an *acute prominent metallick Point* be fixt to the *remote (poſitive)* Body; that the *returning Fluid* will run out of that *remote* Body, with a much greater Degree of *facility* through the *prominent Point*, than it would through any *non-prominent* Point whatever of that *remote* Body.

§ 240. We have alſo ſeen (§ 229), that if an *acute prominent metallick Point* be fixt to the *near (negative)* Body; that, the *returning Fluid* will enter into that *near* Body, with a much greater Degree of *facility* through the *prominent Point*, than it would through any *non prominent* Point whatever of that *near* Body.

§ 241. It is therefore evident, if an *acute prominent metallick Point* be fixt to *each* of thoſe two inſulated Bodies; that, the *returning Fluid* muſt paſs between thoſe *two Bodies*, with a greater Degree of *facility* through the *two prominent Points* oppoſed to each other, than it would through any *non-prominent* Points whatever of thoſe Bodies, or than it would through any *ſingle prominent Point* oppoſed to any *non-prominent* Point whatever of either of thoſe Bodies.

§ 242.

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† § 226 & ſeq.

§ 242. Conſequently, if the (*near*) *negative* Body was obliged, by any cauſe, to have its *deficient* Electricity ſupplied *on a ſudden*, by the *ſuperabundant* Electricity of the (*remote*) *poſitive* Body; it is evident, that the *ſpark*, occaſioned by ſuch an *inſtantaneous Diſcharge*, muſt be able to fly to the *greateſt* Diſtance, in that caſe, in which, the Electricity conſtituting the ſpark meets with the *leaſt Reſiſtance.*

§ 243. The *neceſſary ſuddenneſs* of the *returning Stroke*, was the reaſon, and the only reaſon, of *any ſpark paſſing between the two metallick Points.*

EXPERIMENT 28.

§ 244. Having removed the Bodies SS and XX; I took *two* inſulated braſs Bodies (of the ſize and ſhape of the Body AB mentioned above in § 204) which were perfectly *equal* and *ſimilar* to each other, and which were quite free from Points; and I placed them exactly at *equal Diſtances* from the Prime-Conductor PC, as repreſented by YY and ZZ, in the Figure. Their near Ends were at about *twenty inches* from the Prime Conductor, and at *two inches* aſunder. Their remote Ends were almoſt *in contact* with each other. Fig. 13.

§ 245. But, during the whole Time the Prime Conductor was *receiving its Charge* of Electricity; and alſo, when the *Diſcharge* of the Prime-Conductor PC came to take place upon the Ball L; I could *not* perceive *any ſpark* whatever, between the two inſulated metallick Bodies YY and ZZ.

§ 246. The reaſon of which was evidently this.

Thoſe two Bodies being at *equal* Diſtances from the Prime-Conductor, received from its electrical Atmoſphere ſuperinduced, an *equal Degree* of elaſtick *Preſſure.* Thence, it follows, that one of them had *no more* tendency, to become *poſitive*, or to become *negative*, than the other. Therefore, the *electrical Equilibrium* of the one, relative to the other, was *not* diſturbed, during the Time that the Prime-Conductor PC was receiving its Charge of Electricity.

§ 247. Conſequently, the *Diſcharge* of the Prime Conductor PC (were it ever ſo ſudden upon the Ball L) could occaſion *no ſpark whatever*, between the two *equi-diſtant* and inſulated Bodies YY and ZZ.

This Experiment renders my former explanation, of the *Cauſe of the ſtrong electrical Sparks* ſeen in the *other* Experiments above-related, ſtill (if poſſible) more clear and uncontrovertible.

PART IX.

SECTION 248.

THE next ſet of Experiments I made, was in order to inveſtigate more fully the curious Effects of the *returning Stroke*; and to ſhew in what manner, *Perſons*, either *inſulated* or *not inſulated*, might receive *that kind of electrical Shock*, even without the interpoſition of any metallick Body between them and the *charged Body* in whoſe electrical Atmoſphere they might happen to be immerged.

EXPERIMENT 29.

§ 249. I placed myſelf (in the ſituation repreſented by ABD, in the Figure) upon an inſulating ſtool E; ſo as to have my right arm A, at the Diſtance of about *twenty inches* from a large Prime-Conductor † PC. Fig. 14.

Another perſon FGH, ſtanding upon another inſulating ſtool K, brought his right hand F within *one quarter* of an inch of my left hand B.

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† This Prime-Conductor was the *ſame* as that I before made uſe of (§ 76 and § 204); and it was charged with the *ſame* Apparatus.

§ 250. When the Prime-Conductor PC began to receive its *plus* Charge of Electricity; we felt the electrical Fluid running out of my hand B, into his hand F.

§ 251. When our hands B and F were brought *into cloſe contact*; the Electricity paſſed *imperceptibly* from me to him.

§ 252. When we ſeparated our hands B and F, a little; the Electricity paſſed between us, in ſmall *ſparks*, which ſparks increaſed in *ſharpneſs*, the further we removed our hands B and F aſunder, until we had brought them quite out of a *ſtriking Diſtance*. The intervals of Time between theſe *departing ſparks*, increaſed alſo, the more the Diſtance between our hands B and F was increaſed, as muſt neceſſarily be the caſe.

§ 253. As ſoon as the Prime-Conductor PC came ſuddenly to diſcharge its Electricity, upon the Ball L; the *ſuperabundant* Electricity, which the other Perſon had re-ceived from my Body, did then *return* from him to me, in a *ſharp ſpark*, which iſſued from his hand F, at the very *inſtant* that the *Exploſion* of the Prime-Conductor PC took place upon the Ball L.

EXPERIMENT 30.

§ 254. In order to ſhew, that I (who had been the *neareſt* to the charged Prime-Conductor) had been *negative*, and that the other Perſon had been *poſitive*; I ſuſpended a pair of cork Balls, pretty high up, juſt over the interval between our two hands B and F (as repreſented at S, in the Figure). This Electrometer ſo placed, being within the electrical *Atmoſphere* of the electrified Prime-Conductor PC, divaricated, when the Prime-Conductor was charged. Fig. 14.

§ 255. Whilſt the Prime-Conductor was receiving its Charge of Electricity, I brought my hand B into contact with the other Perſon's hand F. But, before the Diſcharge of the Prime-Conductor PC took place, I let go the other Perſon's hand, in order that I might try, by means of the Electrometer at S, with *what kind* of Electricity I was charged.

Upon approaching each of my hands A and B, one after the other, towards the under ſide of the electrometrical Balls S; thoſe Balls, each Time, were *repelled* and divaricated *leſs*: which ſhewed that my Body was electrified *in minus*; ſince, my Electricity tended to *counteract* the Electricity of the Prime-Conductor, which was, as uſual, electrified *in plus*.

§ 256. But, when the other Perſon approached either of his hands F or G, towards the under Side of thoſe electrometrical Balls S; thoſe Balls were *attracted* and divaricated *more*: which ſhewed that *that Perſon* was electrified in *plus*, agreeably to my former Experiments.

EXPERIMENT 31.

§ 257. The next Experiment I made, was for *both* of us to ſtand upon the *floor*, inſtead of uſing the *inſulating ſtools* above-mentioned; each of us remaining in the *ſame poſition* with reſpect to each other, and at the *ſame reſpective Diſtances* from the Prime-Conductor PC, as in the Experiment 29th above-related (§ 249).

§ 258. The Effect was exactly the ſame as in that Experiment; except that the *returning ſpark*, which paſſed between our hands B and F at the moment of the *ſudden Diſcharge* of the Prime-Conductor, was *leſs* ſtrong, than in the former caſe. The reaſon of it was this.

Part of the Electricity of my Body was expelled into the Body of the other Perſon, and *Part* into the Earth through the floor; ſince, I was *not inſulated* as in the former caſe. Therefore, a *ſmaller Quantity* of electrical Fluid did paſs, between the other Perſon's hand and my hand, on the *ſudden return* of the Electricity, than there did in the 29th Experiment mentioned above. Conſequently, the *ſpark* which did reſult from that *ſudden return* of Electricity, was *leſs ſtrong* in this caſe, than in the former.

EXPERIMENT 32.

§ 259. We then placed ourſelves upon our reſpective inſulating ſtools E and K, again; and we placed ourſelves exactly in the *ſame* poſition we were in, in the

29th Experiment mentioned above (§ 249), only with this difference, that the other Perſon held, in his remote hand, a piece of common ſteel wire (repreſented by GT, in the Figure) which was about *ten inches* in length, and very acutely *pointed* at its Extremity T. Fig. 14.

§ 260. When the Experiment was made, the *returning ſtroke* was rather *ſharper*, than in the 29th Experiment, where the *pointed* metallick wire GT was *not* uſed. The reaſon of it was this.

§ 261. During the Time, that the Prime-Conductor PC was charging with *poſitive* Electricity, the *near* Man ABD was (as we have ſeen above § 254 and § 255) becoming *negative*; and the *remote* Man FGH was, of courſe, becoming *poſitive*. Therefore, the *poſitive* charge of the *remote* Man FGH, cauſed a *greater Degree of Reſiſtance* to the *Entrance* of the electrical Fluid into his Body, than there would have been cauſed had he been *unelectrified*.

Conſequently, the *near* Man ABD could *not* tranſmit into the Body of the *remote* Man FGH, ſo great a Quantity of Electricity, as would have paſſed between them, if the *remote* Man had been either *unelectrified*, or electrified *leſs ſtrongly in plus* than he was: that is to ſay, if the electrical Fluid of the *remote* Man's Body had oppoſed *leſs Reſiſtance*, to the *Entrance* of the Electricity that tended to leave the Body of the *near* Man ABD.

§ 262. Now, the neceſſary conſequence of the ſharp prominent metallick *Point* GT, held out in the left hand of the *remote* Man, was, that a *Part* of his *ſuperabundant* Electricity did run out, through that *Point*, for reaſons explained above (§ 34, § 35 and § 36).

That is to ſay, that the prominent metallick Point T did cauſe the Body of the *remote* Man to contain *leſs electrical Fluid*, than it had done before he made uſe of that *prominent Point.*

§ 263. Therefore, when the *remote* Man held out the *prominent metallick Point* GT, in his hand G; his Body oppoſed *leſs Reſiſtance* to the *Entrance* of the electrical Fluid of the other Man's Body, than when that metallick *Point* was *not* made uſe of.

This neceſſarily cauſed the *near* Man ABD, to become *more negative* than before.

§ 264. It was the *near* Man being rendered *more negative*, that cauſed the *returning ſpark*, which paſſed (at the inſtant of the *ſudden Diſcharge* of the Prime-Conductor) from the hand of the *remote* Man into the hand of the *near* Man, to be rather more ſeverely felt, than it was in the 29th Experiment mentioned above (§ 249).

EXPERIMENT 33.

Fig. 14. § 265. I ſtill continued upon the inſulating ſtool E, and I deſired the other Perſon to ſtand upon the floor. The *returning Stroke* between us was ſtill *ſtronger* than it had yet been. The reaſon of it was this.

§ 266.

§ 266. The other Perſon being no longer *inſulated*, tranſmitted his *ſuperabundant* Electricity freely into the Earth. I conſequently, became ſtill *more negative* than before.

Now, when the *returning Stroke* came to take place; not only the *Electricity*, which had paſſed from my Body into the Body of the *other Perſon*, but alſo the Electricity which had paſſed from my Body into the *Earth* (through the Body of the other Perſon,) did *ſuddenly return* upon me, from his Hand F to my Hand B, at the ſame inſtant that the Diſcharge of the Prime-Conductor took place upon the Ball L. This cauſed the *returning Stroke* to be ſtronger than before.

EXPERIMENT 34.

§ 267. The next Experiment was, for me to ſtand upon the inſulating ſtool E as before, and for the other Perſon to ſtand upon a *ribband of Lead* QR, which was ſtretched along the floor, and had been made to communicate with the Earth. The *returning Stroke* was ſenſibly *ſtronger* in this caſe, than it had been in any of the former Experiments.

§ 268. The reaſon of it was; that, from the *good* metallick *Communication* juſt mentioned, the electrical Fluid of the *remote* Perſon's Body, was enabled to leave it with much *more facility*, than when he ſtood only on the floor. Therefore, the electrical Fluid of my Body was able to leave my Body, with *more facility* alſo. Conſequently, the expelled Electricity did *ſuddenly return* into my Body, in a greater Quantity, and with more Power, than before.

EXPERIMENT 35.

§ 269. I then made the Experiment of the *returning Stroke*, without any Perſon ſtanding near me. I placed myſelf, upon the floor, a little beyond the *ſtriking Diſtance* of the large Prime-Conductor, as I had in the Experiments mentioned above.

§ 270. Whilſt the Prime-Conductor was charging, I Fig. 14. held my *remote* hand, very near the upper End M of a metal Stand MN, which communicated with the Earth by means of a ribband of Lead QR.

§ 271. When the Diſcharge of the Prime-Conductor took place upon the Ball L; I felt a *ſharp returning Spark*, between my remote hand and the upper End of the metal Stand juſt mentioned. The reaſon of which was the ſame, as in the former Experiments.

EXPERIMENT 36.

§ 272. I repeated this Experiment, ſtanding upon an *inſulated ſtool*, and I found that the ſharpneſs of the *returning ſpark* was increaſed. The reaſon of which evidently was; that, the electrical Fluid, which was expelled from my Body during the Time that the Prime-Conductor

-tor was charging, did ſuddenly *return* upon me, all *one* way; namely, through the metal Stand: inſtead of returning *different* ways, as in the laſt Experiment; *videlicet*, Part through my hand from the Stand, and Part through my feet from the Floor upon which I ſtood.

EXPERIMENT 37.

§ 273. I then repeated an Experiment, ſimilar in principle to *that* mentioned above (§ 244), which was made with *two equal* and ſimilar metallick Bodies, that were placed at *equal Diſtances* from the Prime-Conductor. It was as follows.

§ 274. I placed myſelf near the Prime-Conductor, upon an inſulating ſtool; my *neareſt* Arm being at the Diſtance of about *twenty inches* from the charged Body.

The other Perſon placed himſelf, in a poſition exactly *ſimilar* to mine, and alſo at the *ſame Diſtance* from the Prime-Conductor. He alſo ſtood inſulated as I did. The Diſtance between our two Bodies was about *twelve* or *fourteen inches*. We then brought our *remote* hands, almoſt *into contact*.

§ 275. Now, when the *ſudden Diſcharge* of the Prime-Conductor, came to take place upon the Ball L; there did *not* paſs any Spark or Stroke whatever between us, in this caſe.

§ 276. The

§ 276. The reaſon of this clearly was; that we were both *equally* acted upon, by the *ſuperinduced elaſtick Electrical Preſſure* of the Prime-Conductor's electrical Atmoſphere; ſince, we were both *equally diſtant* from that charged Body, and *ſimilarly* ſituated with reſpect to it.

Conſequently, a *Phenomenon*, the original *Cauſe* of which I have demonſtrated to be an *inequality* of electrical action, could evidently *not* exiſt in the preſent inſtance.

PART X.

PART X.

SECTION 277.

HAVING made a great number of Experiments, ſimilar in principle to thoſe above-mentioned, yet variouſly diverſified; I ſhall give an account of a few of them, which appear to me to be particularly intereſting and important.

I conceived very early, that one effectual way of *increaſing the force* of (what I call) the *returning Stroke*, or of increaſing the *Diſtance*, at which it might be felt from the charged Body, would be, to increaſe the *Surface* of the conducting Bodies placed within the *electrical Atmoſphere* of the electrified Prime-Conductor.

§ 278. Becauſe, the greater that *Surface* is, the greater alſo muſt the *Quantity of Electricity* be, that can be *tranſmitted from* that Surface, during the Time that the Prime-Conductor is receiving its *poſitive* Charge of Electricity.

Therefore, the greater alſo muſt the *Quantity of Electricity* be, which forms the *returning Stroke*.

§ 279. Conſequently, the greater muſt the *Force* be, *(cæteris paribus)* of the *returning Stroke*; and the greater muſt the *Diſtance* be, at which it may be felt, from the charged Body.

I verified this ſuppoſition, in the following manner.

EXPERIMENT 38.

§ 280. I made uſe in the following Experiments, of the ſame Prime-Conductor that was mentioned above (§ 76 and § 249).

In this ſet of Experiments, its *ſtriking Diſtance*, upon Fig. 15. a braſs Ball L of four inches diameter (which had a proper metallick Communication with the Earth), was generally about *ſeventeen inches*.

§ 281. At the Diſtance of *ſix feet* from the Prime Conductor PC, I placed an inſulated cylindrical Body IQ, which was about four feet four inches long by ſeven inches diameter, and which was covered with Tin-foil.

§ 282. I then placed, in *perfect contact* with that Fig. 15. Body IQ, another inſulated cylindrical Body OT (as repreſented in the Figure), which Body OT was of Braſs, and was forty inches long by about three inches and three quarters diameter.

§ 283. Both the Bodies IQ and OT were perfectly free from *Points*, and *ſharp edges* of every kind.

§ 284.

§ 284. I placed myſelf (in the Poſition repreſented by ABD, in the Figure,) upon an inſulating ſtool E; holding my right hand A, ſo as juſt *very lightly* to touch the metallick Body TO. Fig. 15.

§ 285. Another Perſon (repreſented by FGH, in the Figure,) then placed himſelf upon an inſulating ſtool K; holding his right hand F as cloſe to my left hand B, as he poſſibly could, without bringing it quite *into contact*. That Perſon then held his left hand G, ſo as to touch *very lightly* the upper End R, of a metallick Stand RV, which communicated with the Earth, by means of a ribband of Lead XX.

§ 286. Now, when the Prime-Conductor PC came ſuddenly to diſcharge, with an Exploſion, its *ſuperabundant* Electricity upon the Ball L; we, at the ſame inſtant, very ſenſibly felt the *returning Stroke*: and when we received it through the tips of our fingers, we felt it pretty much.

§ 287. We have ſeen above (§ 280 and § 281), that the *ſtriking Diſtance* of the Prime-Conductor PC upon the Ball L, was about *ſeventeen inches*; and that the Body IQ (which was the *neareſt* of the two inſulated Bodies IQ and OT) was at the *Diſtance* of *ſix feet* from that ſame Prime-Conductor.

I believe therefore, that no one will deny, that the Bodies IQ and OT were ſufficiently *out of the ſtriking Diſtance* of the Prime-Conductor, for the Prime-Conductor's electrical *Charge* not (in any degree) to *divide* itſelf, and to go *different ways*, at the inſtant of the

Exploſion; as ſome Perſons would perhaps have been inclined to imagine, if the Experiment had been made with the Bodies IQ and OT placed only *juſt beyond the ſtriking Diſtance* of the Prime-Conductor.

But, what is contained in the foregoing Pages, is more than ſufficient to give ſatisfaction upon *that* head, to any Perſon who ſhall have peruſed them with due attention.

EXPERIMENT 39.

§ 288. I then decreaſed the *Diſtance*, between the Bodies IQ, OT, and the Prime-Conductor, from *ſix feet* to *five feet*, then to *four feet*, then to *three feet and a half*, and then to *three feet*.

§ 289. Whilſt the Prime-Conductor was receiving its Charge of Electricity; we felt the electrical Fluid, which was expelled from the Bodies IQ and OT, paſſing in ſmall *ſparks* between my hand B and the other Perſon's hand F.

§ 290. The more I decreaſed the *Diſtance*, between the Prime-Conductor and the two inſulated Bodies; the more I found, that the ſtrength of the *departing ſparks*, and that the ſtrength of the *returning Stroke*, did increaſe.

§ 291. The reaſon of this evidently was; that the *nearer* the Bodies IQ and OT were brought to the Prime Conductor; the more they were rendered *negative*, by the ſuperinduced elaſtick electrical *Preſſure* of that Prime Conductor's *poſitive* Atmoſphere.

The *Quantity* therefore, of electrical Fluid, which was *expelled* from the Bodies IQ and OT (whilſt the Prime Conductor was charging), was increaſed; which increaſed alſo the ſtrength of the *departing ſparks.*

Conſequently, the ſtrength of the *returning Stroke* (which was proportional to the *Sum* of all the *departing ſparks*) was of neceſſity, increaſed likewiſe.

§ 292. I obſerved, in making this ſet of Experiments, that the *ſtriking Diſtance*, of the Prime-Conductor PC upon the Ball L, was not at all *diminiſhed*; the Weather, in which theſe Experiments were made, being dry.

The reaſon of this was;

1ſt. That the Bodies IQ and OT were perfectly *free from Points* (ſee § 283);

And 2dly. That the Communication, between thoſe two Bodies IQ, OT, and the Earth (through our Bodies, the metal Stand, &c.) was an *imperfect Communication.*

§ 293. This is another proof, that the Effect which I call the *returning Stroke*, was *not* occaſioned, by the electrical Charge of the Prime-Conductor being any-wiſe *divided* at the time of the Exploſion.

EXPERIMENT 40.

§ 294. I then decreaſed the *Diſtance*, between the Bodies IQ, OT, and the Prime-Conductor PC, from *three feet* to *two feet and an half*, then *to two feet*, then to *twenty inches*, and then to *eighteen inches*.

§ 295. The ſtrength of the *returning Stroke* was conſiderably increaſed, upon my bringing the two Bodies *nearer* to the Prime-Conductor. But the *ſtriking Diſtance* of the Prime-Conductor PC upon the Ball L was ſomewhat *decreaſed*, upon my approaching the two Bodies IQ and OT, as near as I then did to the Prime Conductor.

§ 296. The reaſon of this was *not*, that the electrical *Charge* of the Prime-Conductor, did *divide* itſelf, at the Time of the *Exploſion*; but, that the ſtrength of the ſuperinduced elaſtick electrical *Preſſure* of the Prime-Conductor's *plus* Atmoſphere, was ſufficient (under the circumſtances then exiſting,) to cauſe a certain Degree of *electrical ſilent Diſcharge* to take place, from the Prime-Conductor through the Bodies IQ and OT, whilſt the Prime-Conductor was receiving its *Charge* of Electricity. Becauſe, my Body ABD, the other Perſon's Body FGH, the metal Stand RV, and the ribband of Lead XX, formed a kind of *Communication* (however *imperfect*), between the Bodies IQ, OT, and the Earth; ſince the *interruptions* at A, at F, and at R, were but extremely *ſmall*.

EXPERIMENT 41.

§ 297. The Diſtance, between the Prime-Conductor and the *neareſt* of the two inſulated Bodies IQ and OT, being *twenty inches*; that is to ſay, only *three inches* *more*

more than the *ſtriking Diſtance* of the Prime-Conductor PC upon the Ball L, which (we have ſeen above, § 280) was about *ſeventeen inches*; I could not perceive any ſenſible *diminution* in the *ſtriking Diſtance* of the Prime Conductor: provided that the Air of the Room was *not damp*; that is to ſay, that it was not itſelf a *Conductor* of Electricity: provided that I did *not* bring my hand A, quite *into contact* with the Body OT: and provided that the other *inſulated* Perſon FGH (inſtead of bringing his left hand, as repreſented by G in the Figure, into light contact with the metal Stand RV), did keep his left hand by his ſide, as repreſented by the *dotted Lines* at M, in the Figure; that is to ſay, provided our two Bodies ADB and FHG did *not* form, ſo much as even an *imperfect Communication* between the Bodies IQ, OT, and the Earth. Fig. 15.

§ 298. The *returning Stroke* took place in this caſe, nevertheleſs; tho' it was not ſo ſtrong as before, for reaſons of a ſimilar nature to thoſe which have been explained above (§ 266 and § 268).

§ 299. The exiſtence, in *this* inſtance, of the *Effect* which I call the *returning Stroke*, was an evident proof, that *that Effect* was *not* occaſioned, by the electrical Charge of the Prime-Conductor being any wiſe *divided* at the Time of the Exploſion.

EXPERIMENT 42.

§ 300. In order, to be able (whilſt the other Perſon was forming a *Communication* with the Earth, by hold-

-ing his hand G in contact with the metal ſtand RV) to bring the Bodies IQ, and OT, juſt ſo cloſe to the Prime-Conductor PC, as to be but *very little* beyond the *ſtriking Diſtance* of that charged Body; I brought the metal Ball L, to the Diſtance of *thirteen inches and a half*, from the Ball C of the Prime-Conductor.

§ 301. I then decreaſed the *Diſtance*, between the Bodies IQ, OT, and the Prime-Conductor PC, from *eighteen inches* to *ſixteen inches*, then to *fifteen inches*, and then to *fourteen inches*.

§ 302. During the whole Time that the Prime-Conductor PC was receiving its Charge of Electricity; we felt a prodigious number of *ſharp ſparks*, paſſing from my hand B to the other Perſon's hand F.

The nearer we brought our hands together, the ſmaller, and the leſs ſharp, thoſe *departing ſparks* were; and the more they reſembled a continued *ſtream* of electrical Fire.

But when, on the contrary, we moved our hands as far aſunder, as thoſe *departing ſparks* could ſtrike (i. e. about *half an inch* aſunder; the Diſtance between the near Body IQ, and the Prime-Conductor, being *fourteen inches*); then, thoſe *departing ſparks* became almoſt too ſharp and too painful, for us to be able to bear a long ſucceſſion of them; particularly, when they were tranſmitted, or received at the Ends of our fingers.

§ 303. Now, when the Prime-Conductor PC came ſuddenly to diſcharge with an *Exploſion*, its *ſuperabundant* Electricity upon the Ball L; the *electrical Fluid*, which had been *expelled* from the metallick Bodies IQ, and OT, into the Earth (through our Bodies ADB and FHG, through the metal Stand RV, and the ribband of Lead XX), did *ſuddenly return*, by the ſame Conductors, into the Place it before occupied; flying acroſs any *ſmall interruptions* it found in the Communication.

§ 304. The conſequence of this was, that we not only (both of us) felt a ſevere *electrical Stroke*, in each of our hands; but, we (both of us) received a violent *Commotion*, through our arms and cheſts; which Commotion I can compare to nothing, *except to the ſingular ſenſation which is felt by a Perſon, when a Leyden Jar ſtrongly electrified, is ſuddenly diſcharged through his Body*.

§ 305. I repeated, at different Times, this Experiment various ways; namely, with *one* Man, or with *two* Men; with both Men *inſulated*, or with both *ſtanding on the floor*; with the *near* Man inſulated, and the *remote* Man *not* inſulated; with the *remote* Man inſulated, and the *near* Man ſtanding on the floor; with *one* of the Men, or with *both* of them, holding one or more metal *Balls*, or one or more metal *Points*, in *either* of their hands, or in *both*, &c. &c.

The *Effects* were always conſiderable; but, they varied as to *ſtrength*, nearly in the *ſame* manner as they did in the Experiments above-related.

EXPERI-

EXPERIMENT 43.

§ 306. One Experiment worth notice was; that when I held in my remote hand B, a ſharp metallick *Point*; and that the other Perſon held in his near hand F, another ſharp *Point*; I often obtained between theſe *two* Points, a very ſharp *returning ſpark* an *inch and a half* long.

The reaſon, why a *returning ſpark* was able to fly from one *ſharp Point* to another, has been fully explained above (from § 238, to § 243 incluſively).

§ 307. I found that the moſt effectual way to obtain (with the *given* Apparatus, and the *given* inſulated conducting Bodies IQ and OT, above-mentioned) a very *ſtrong returning Stroke*, was;

1ſt. To place the Bodies IQ and OT, in the *denſeſt Part*, of that Part of the Prime-Conductor's *electrical Atmoſphere*, where they were out of danger of having their *deficient* Electricity ſupplied from the charged *Prime-Conductor itſelf*; that is to ſay, only juſt beyond the *ſtriking*† *Diſtance* of the Prime-Conductor.

2dly. To place myſelf (or the other Perſon and myſelf, when we made the Experiment jointly), in an *inſulated ſituation*.

3dly. To make a *perfect metallick Communication*, from the metal Stand RV to the Earth.

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† That is, in the Caſe before us, at the Diſtance of *fourteen inches* from it; ſee § 300 and § 301.

And 4thly. To make the *Communication*, between the Bodies IQ, OT, and that metal Stand, *imperfect*; by always taking care, *never* to have a very *cloſe contact* formed either at A, at F, or at R.

§ 308. If theſe things were done in making the Experiment; the *returning Stroke* was always extremely ſevere and pungent.

Nay, this *returning Stroke* appeared to me to be *conſiderably ſharper*, than even the *main Stroke* itſelf which was diſcharged from the Prime-Conductor PC upon the Ball L: tho' the *returning Stroke* (with the Apparatus † above deſcribed,) was *not* perhaps quite ſo *full*.

This is another unanſwerable proof, that the *Effect* which I call the *returning Stroke*, was *not* produced by the *main Stroke* being any wiſe *divided* at the Time of the Exploſion. Since, *no Effect* can ever be greater than the *Cauſe*, by which it is *immediately* produced.

§ 309. In order to judge well of the *comparative ſharpneſs* of theſe two kinds of Strokes, I received the *main Stroke* alſo, at ſeveral different Times, by making my two Arms and my Body, a Part of the conducting *Communication* between the metal Ball L and the common-Stock.

§ 310. If the Experiment of the *returning Stroke*, were made in the manner above deſcribed (§ 307), the *returning*

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† When a ſimilar Experiment was performed with another Apparatus, the *ſtrength* of the *returning Stroke* was conſiderably increaſed; tho' the *main Stroke* was *weaker*, as will be related hereafter.

returning Stroke was always extremely pungent: ſo that, having taken it, eight or ten Times, one morning (without having taken the *main Stroke* a ſingle Time, that Day); I felt a conſiderable degree of pain a-croſs my Cheſt during the whole Evening, and a diſagreeable ſenſation in my Arms and Wriſts all the next Day.

PART XI.

PART XI.

SECTION 311.

LET us now make the *application* of the above-mentioned electrical Experiments, to the caſes which may exiſt in *natural Electricity*.

Inſtead of an electrified Prime-Conductor, let us ſuppoſe a *real Cloud* ABC charged with Electricity. And let Fig. 16. us ſuppoſe, that there be *Perſons*, ſtanding either inſulated or *not* inſulated, either near each other, or near ſome conducting Body or Bodies of any kind whatever; provided thoſe Bodies be *not Conductors* well connected with the Earth, and terminating at their upper Extremity in *prominent* † *Points:* then, I ſay, that thoſe *Perſons*, if they be *ſuperinduced* by the Thunder-Cloud's *electrical Atmoſphere*, may (under circumſtances ſimilar to thoſe above-explained,) receive that kind of *electrical ſhock*, which I have, in the foregoing Pages, called a *returning Stroke*: and that, if thoſe Perſons be *ſtrongly ſuperinduced* by the *electrical Atmoſphere* of the Cloud, they may (under circumſtances ſimilar to thoſe explained above,) receive a very *ſtrong ſhock*, be knocked down, or be even *killed*, at the Inſtant that the Cloud diſcharges, with an *Exploſion*, its Electricity; whether the Lightning falls *near the very Place* where thoſe Perſons are, or at a *very conſiderable Diſtance* from that Place; or whether the Cloud be *poſitively* or *negatively* electrified.

P So

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† The reaſon for *this exception* will be ſeen hereafter.

So that, a *Perſon*, placed (for inſtance) upon the Surface of the Earth at F, and ſtrongly *ſuperinduced* by the *electrical Atmoſphere* of the Cloud ABC, might receive a violent *returning Stroke*; even, if the *main Exploſion* (which produces the *returning Stroke*) were to take place, at the moſt *remote* Extremity C of that Thunder-Cloud.

§ 312. Were the queſtion to be put, "*at what Diſtance* from the *Place* where the Lightning falls, a "Perſon might be knocked down, or even killed, by "that *electrical Effect*, which I have, in the foregoing "Pages, called a *returning Stroke*"; the accurate anſwer to be returned would be:

That, "as far as a *ſingle** Thunder-Cloud which is "all *poſitive*, or as far as a *ſingle* Thunder-Cloud which "is all *negative*, *does extend a ſtrong elaſtick electrical* "*Preſſure, on any ſide from the Place where the Lightning falls*; ſo far from *that Place*, may a Perſon be "knocked down, or even *killed*, at the inſtant of the "*remote Exploſion*; provided that he be under circum"-ſtances ſimilar to thoſe explained above."

So that, under thoſe circumſtances, fatal Effects may be produced by the electrical *returning Stroke*, at as *great a Diſtance* [at leaſt] *from the Place where the Lightning*

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* I would here define a *ſingle* Thunder-Cloud (in contradiſtinction to an *aſſemblage* of Clouds), to be, a Cloud which is charged *throughout* with one and the *ſame* kind of Electricity; and in ſuch a manner, that, if a *Diſcharge* ſhould take place from any Part of this Cloud, it ſhould tend, nearly in a proportional Degree, to *unelectrify* the remoteſt End of ſuch a Cloud.

I do *not* mean, however, to ſuggeſt, that the *returning Stroke* could never be produced by an Exploſion, which might proceed from an *aſſemblage* of different Clouds; for, in certain caſes, it neceſſarily would.

-ning falls, as the ſingle *poſitive* (or as the ſingle *negative*) Cloud, that occaſions the *main Exploſion*, can extend itſelf, on *any* ſide from *that Place*. But, it is evident, that the above-mentioned circumſtances *cannot exiſt*, if the Cloud be too much elevated above the Surface of the Earth at the Time of the Exploſion.

§ 313. Whether, the *Diſtance*, between the Perſon ſo circumſtanced, and the *Place* where the Lightning falls, be *fifty* or an *hundred Yards*, or *one Mile*, or *two Miles*, or *three Miles*, or more; the *truth of the general Propoſition* here-laid-down will *not* be any-wiſe affected: and there is not, in my opinion, the ſhadow of a doubt, but that, that ſpecies of *electrical ſhock*, which I have diſtinguiſhed by the name of a *returning Stroke*, might produce moſt fatal Effects at a *prodigious Diſtance from the Place where* the *Lightning falls*.

§ 314. There is one conſequence, that muſt neceſſarily follow from the Principles above-laid-down, which is no leſs ſingular, than it is important.

It is, that an Exploſion, which happens in *one* Place, may cauſe in a *ſecond* Place (at a very conſiderable Diſtance from the *firſt* Place), a ſudden *returning Stroke*, which may knock down, or even kill, Perſons and Animals, in that *ſecond* Place; at the ſame Time, that other Perſons, or other Animals, ſituated in a *third* Place, that is even immediately *between* the *firſt* Place where the *Lightning falls*, and the *ſecond* Place (juſt-mentioned) where the ſhock of the *returning Stroke* happens, ſhall receive no detriment whatſoever.

§ 315. For, ſhould a large ſingle Cloud ABC charged with Electricity, be at a very conſiderable height, ſo Fig. 16.

that,

the *inverſe ratio of the ſquare of the Diſtance*; as I have fully proved, in the foregoing Pages.

§ 319. If a Man therefore, ſhould be killed, by that Stroke of Lightning which I call the *returning Stroke*; if any Perſon, (ever ſo converſant in *all* the Laws of Electricity *hitherto known*) ſhould find that Man's Body; and if it ſhould evidently appear (by examination of that Man's Body) that he had been killed by Lightning: it is quite impoſſible to conceive, that it could ever once come into ſuch a Perſon's head to imagine, that it was the Electricity of the *dead Man's own Body*, and that it was *not the Matter of Lightning diſcharged from the Thunder-Cloud* (*ſome Part* of which had been floating directly, or almoſt directly *over that very Place*), that was the *immediate Cauſe* of that Man's deſtruction.

§ 320. Neither is it poſſible, that this Perſon ſhould imagine; that, that Man had *not* been killed by any electrical Exploſion taking place *near the ſpot* where he was found dead; but, that he had loſt his life by *a particular Effect, which proceeded from an electrical Exploſion that took Place at the Diſtance of perhaps more than a Mile.*

§ 321. Therefore, whenever any Men, or any Animals, have *hitherto* been killed, by that electrical ſhock which I call the *returning Stroke*; the death of ſuch Men or Animals, muſt always have been aſcribed to the *common Stroke of Lightning*. For, it is evident, that *no Perſon* could ever *yet* have aſcribed the above-mentioned *Effect*, to the *proper Cauſe*; ſince, the *very poſſibility* of the exiſtence of ſuch a *Cauſe* had *not been previouſly* demonſtrated, or even *previouſly* conceived.

Conſequently, *our* NOT *having hitherto been able to find out a particular hidden Cauſe*, muſt *not* (when that Cauſe is actually diſcovered,) be brought as an argument againſt the *exiſtence* of ſuch a Cauſe.

§ 322. But now, that I have fully ſhewn the *poſſibility* of Perſons and Animals being knocked down, or even killed, by a *particular Effect*, produced by a *diſtant Exploſion* from a Thunder-Cloud; it will be in our power, to account for *many electrical Phenomena*, which we were before unable to explain; and to determine *in what manner*, ſeveral ſtrange kind of accidents reſulting from natural Electricity, are occaſioned.

§ 323. It has often happened in violent Thunder Storms, that Perſons, at great Diſtances from each other, have been all *knocked down at once* (tho' perhaps otherwiſe not hurt), at the *very inſtant*, in which, ſome great Exploſion from the charged Cloud took place.

§ 324. I am of opinion, that *this Effect* is always occaſioned by the electrical *returning Stroke*.

For, if thoſe Perſons had been *much* within the *electrical Atmoſphere* of the Cloud, before its *ſudden* Diſcharge took place; they muſt, during the approach of the [*poſitive*] Cloud, have been *gradually rendered negative*, by the increaſing Force of the *ſuperinduced* elaſtick electrical *Preſſure*, of the Cloud's electrical *Atmoſphere*.

§ 325. Conſequently, thoſe Perſons, at the moment of the Exploſion, muſt have received a *ſtrong ſhock*, from the *ſudden return* of the Electricity, which had been *gradually* (and perhaps *imperceptibly*) expelled from their Bodies, into the Earth.

I am the more perſuaded, that the Effect above-mentioned is always produced by an electrical *returning Stroke*; becauſe, there is no other explanation of this Effect that is *not* unſatisfactory.

§ 326. There have been inſtances of Perſons, who have been killed by *natural* Electricity, having been found with their *ſhoes torn*, and with their *feet* damaged by the electrical Fire; but, who have *not* had, over their *whole Body*, any other apparent marks of having been ſtruck with Lightning.

§ 327. This Effect is moſt eaſily to be accounted for, by means of the electrical *returning Stroke*.

For, it is evident; if a Man walking out of doors, were to be killed by a *returning Stroke*, that the electrical Fire would ruſh into that Man's Body, through his *feet*, and his feet *only*; which would *not* be the caſe, were he to be killed by any *main Stroke* of Exploſion either *poſitive* or *negative*.

§ 328. If any Animals had been killed by Lightning, and if any Perſon [who had been, during the Thunder

Storm, within about *four* or *five hundred Yards* of the Place where the cattle were found dead,] had very attentively obſerved the Storm, and had taken notice, that, during the whole Time of its continuance, *the interval between the flaſh and the report* was never *leſs* than about *ſix ſeconds* ; then, it is evident that *no Exploſion* from the Thunder-Cloud could have taken place, within the Diſtance of at leaſt *one Engliſh Mile* from *the Place* where the cattle were killed.

I think, that in ſuch caſes, there can be no doubt, that the Effects produced, muſt be occaſioned by that kind of electrical ſhock, which I have called the *returning Stroke.*

§ 329. I have been credibly informed, that a Perſon (at *Vienna*) received an *electrical ſhock*, by having held one hand accidentally *in contact* with an *interrupted* metallick conducting Rod, at the *inſtant* that a *diſtant Exploſion* took place from a Thunder-Cloud.

The *Exploſion* was conjectured to be, at above *half an Engliſh Mile*, from the Place where the Perſon then was.

§ 330. It is evident, that ſince, the *Exploſion was diſtant*; the conducting Rod could *not have been ſtruck*. And it is alſo evident from what has been ſaid above, that ſince, the Rod † *was not ſtruck*; the Effect produced

(namely,

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† N. B. The conducting Rod being *interrupted*, was the true Cauſe of a *returning Stroke* taking place, in this inſtance.

(namely, the *electrical ſhock* which the above-mentioned Perſon did receive,) muſt have been occaſioned by the electrical *returning Stroke*, and that it could *not* have been produced in any other way.

§ 331. Several Electricians (without being able to aſcertain the *Cauſe* of the following *Phenomenon*) have obſerved, whilſt they have been making obſervations upon the Electricity of the Clouds, by means of metallick conducting Rods which had an *interruption* intentionally left in them, for the purpoſe of applying experimental Bells, &c; that, there has been a very ſtrong, bright and ſudden *Stroke* of electrical Fire, in the *interruption* of the conducting Rod; tho' the *Conductor itſelf was not ſtruck by Lightning*: which fact (of the Conductor's *not having been ſtruck*) was fully proved, by the *ſharp Point* of the Conductor *not* being melted or even tinged; and alſo, by the other *circumſtance* mentioned in the middle of the *next* SECTION.

§ 332. They did obſerve moreover, that this ſtrong *Stroke* of electrical Fire, appeared in the *interruption* of the metallick Rod, *at the very inſtant* that ſome *diſtant Exploſion* took place from the Thunder-Cloud. And the *interval which there was between the flaſh and the report* was an evident proof, that the *Exploſion* from the Thunder-Cloud had *not* been very *near the Place* where they then were.

It appears to me almoſt impoſſible, that any Electrician, who has attentively examined what is contained in the foregoing Pages, can forbear conſidering *this Phenomenon*, *as the Effect of a returning Stroke.*

§ 333. From what has been ſaid, it is very eaſy to underſtand, not only in what manner, *Perſons* and *Animals* may be deſtroyed, but how *particular Parts of Buildings* may be conſiderably damaged, by an electrical *returning Stroke*, occaſioned even by ſome *very diſtant Exploſion* from a Thunder-Cloud; namely, *all theſe Parts*, where there is, in any kind of *conducting ſubſtance*, or *ſubſtances* (upon which, a ſtrong elaſtick electrical *Preſſure* is *ſuperinduced*,) any kind of electrical *interruption*, acroſs which the *returning electrical Fire* might ſuddenly ſtrike, and might thereby rend and deſtroy all the Bodies that it might meet with in its paſſage.

§ 334. It moreover evidently follows, from all that has been ſaid above; that, if a Building were to have its Roof entirely covered with *Copper* or with *Lead*, even ever ſo perfectly *connected* by proper *metallick Conductors* with the *Earth*; *particular Parts* of ſuch a Building might, notwithſtanding, be conſiderably damaged by the extenſive conſequences of the electrical *returning Stroke:* provided, *any conducting Parts* of that Building (which were *not* properly connected with ſome one of the *uninterrupted metallick* Conductors, that were made to communicate with the *common Stock*,) were to be *ſo ſituated*, as to be able, juſt before the Time that the *Exploſion* from the Thunder-Cloud takes place, to receive a *conſiderable Degree* of elaſtick electrical *Preſſure*, from the *electrical Atmoſphere* of that Thunder-Cloud.

§ 335. In like manner, and for reaſons of a ſimilar nature; *Perſons* who inhabit an Houſe roofed throughout with *Lead*, which is even perfectly *connected* by proper *metallick Conductors* with the common-Stock, are by no means, in *perfect ſecurity* during a Thunder-Storm; on account of the powerful Effects, that may be produced by the electrical *returning Stroke*, when the elaſtick electrical Preſſure *ſuperinduced* is very ſtrong. Tho', at the ſame time, there cannot be a doubt, but that *Perſons* would be in *much leſs danger* in ſuch a kind of Building, than they would be, in any common Houſe.

§ 336. Nay, I will go further. The influence of the electrical *returning Stroke* explained above, is, in its very nature, ſo extenſive; that, when the elaſtick electrical Preſſure *ſuperinduced* is very ſtrong, *Perſons* are by no means, *perfectly ſecure* during a Thunder-Storm, even if they be perfectly *inſulated*, upon good *non-conductors*, in the middle of a large room; as muſt evidently appear from my 16th, 21ſt, 24th, 27th, 29th, 32nd, and 41ſt, Experiments above-mentioned: provided, thoſe Perſons be *not* inſulated *ſeperately*; and provided alſo, they be *not* at ſome pretty conſiderable Diſtance from all kind of *conducting ſubſtances*, *inſulated*, as well as *uninſulated*.

§ 337. It is not impoſſible, that it may, by ſome Perſons, be objected to me;

" That, altho' all the Effects of an electrical " *returning Stroke*, which have been mentioned in the " foregoing Pages, might take place in a *ſmall Degree* ; " yet, *thoſe Effects could not be ſufficiently powerful* to " knock down (much leſs to *kill*) *Perſons* and *Animals*, " and to do conſiderable *damage* to particular Parts of " *Buildings*, at any *very great Diſtance from the Place* " *where the Lightning falls:* eſpecially, conſidering the " *ſmall Quantity of electrical Fluid*, that is contained in " a *Perſon's Body*, or in any *particular Part* of a Building. " That is to ſay, conſidering the *ſmall Quantity* of electrical Fluid, that can, by being *diſturbed*, produce the " *returning Stroke*.

§ 338. In anſwer to this, I ſhall, in the *firſt* place, take notice ; that (from the very nature of an electrical *returning Stroke*), the *greatneſs of the Diſtance from the Place where the Lightning falls* cannot, in any reſpect, *decreaſe the ſtrength of the returning Stroke*, when the *Degree* of the *ſuperinduced* elaſtick electrical *Preſſure* is GIVEN: ſince, it is only the *ſudden removal of that Preſſure*, which does produce the *returning Stroke*.

Now, ſince, the electrical *returning Stroke* may, under certain circumſtances, take place (as was ſaid above, § 312), *at leaſt* at as *great a Diſtance from the Place where the Lightning falls*, as the *ſingle* Thunder-Cloud which occaſions the *main Exploſion*, does extend itſelf, on *any* ſide, from *that Place*; and ſince, *large* Thunder-Clouds (*cæteris paribus*) are *more powerful*, than *ſmall* ones: it neceſſarily follows, that the *Diſtance*, at which, the electrical *returning Stroke* will (in certain caſes) take place, may be *exceedingly conſiderable* indeed: and it follows alſo, that the *ſtrength* of the *returning Stroke* will *not* be any-wiſe *decreaſed*, by that *Diſtance* being thus *conſiderable*; provided always, that the elaſtick electrical *Preſſure* (of the Thunder-Cloud's electrical Atmoſphere) *previouſly ſuperinduced*, be as *ſtrong*, in the caſe of the *diſtant*, as in the caſe of the *near*, *main Exploſion*, which occaſions the *returning Stroke*.

§ 339. Neither is there any more weight, in the *ſecond* Part of the Objection ſtated above (in § 337), *videlicet*:

" That, the *Quantity of electrical Fluid* contained in
" a *Perſon's Body* (or in any *particular Part* of a Building)
" is ſo *ſmall*, that the *Effect*, produced by ſuch a *ſmall*
" Quantity of Electricity being *diſturbed*, can be but
" *inconſiderable*."

For, tho' it be an undoubted Truth, that the *ſtrength* of the *returning Stroke* muſt (*cæteris paribus*) be always effectually *increaſed*, when the *conducting Surface*, upon which a *given* electrical Atmoſphere is *ſuperinduced*, comes to be *increaſed*; as muſt appear, by conſidering what was ſaid † above, and by comparing the Experiments contained in PART X, with the Experiments that were related before: yet, it will alſo appear, by comparing my Experiment 39th, with my Experiment 38th; my Experiment 40th, with my Experiment 39th; and my Experiment 42nd, with my Experiment 40th;

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† Compare § 212 & *ſeq*, with § 204 & *ſeq*; ſee alſo § 277 & *ſeq*.

that, the *ſtrength* of the electrical *returning Stroke* may be effectually *increaſed* likewiſe, by *other* means; namely, by *increaſing the electrical Denſity, of the electrical Atmoſphere ſuperinduced.*

§ 340. And it follows, from the very nature of the electrical *returning Stroke*, as explained above, and from the important *Propoſitions* ſtated in PART III; that, the *ſtrength* of the *returning Stroke* will *(cæteris paribus) increaſe* in the *ſame Ratio*, as the *Denſity* of the *plus*, or as the *Denſity* of the *minus*, Electricity, which is contained in the *electrical Atmoſphere ſuperinduced.*

That is to ſay, that the *ſtrength* of an electrical *returning Stroke*, produced from a *given* conducting Body, of a very *ſmall ſize*, by the *ſudden* removal of the elaſtick electrical Preſſure of the *ſuperinduced electrical Atmoſphere of a Thunder-Cloud*; is *(cæteris paribus)* as much *more conſiderable*, than the *ſtrength* of a *returning Stroke*, produced from the *ſame given* conducting Body, by the *ſudden* removal of the elaſtick electrical Preſſure of the *ſuperinduced electrical Atmoſphere of a given Prime-Conductor*; as the *electrical Denſity*, of the *ſuperinduced* electrical Atmoſphere of the *Thunder-Cloud*; is *more conſiderable*, than the *electrical Denſity*, of the *ſuperinduced* electrical Atmoſphere of the given *Prime-Conductor*.

§ 341. If the *given* Body juſt-mentioned were of a *large*, or even of a *moderate* (inſtead of a very *ſmall*) *ſize*; then, the *Ratio* here-ſtated would be *ſtill more increaſed.* Becauſe, it is evident, that only a *ſmall Part* of the Surface of a *large* Body, can be ſtrongly *ſuperinduced* by the *electrical Atmoſphere of a Prime-Conductor:* whereas, the *compaſs* † (as well as the *ſtrength)* of the electrical Preſſure, of a *Thunder-Cloud's electrical Atmoſphere*, is immenſe.

So that, the *ſtrength* of an electrical *returning Stroke* will, in *ſuch* kind of caſes, *increaſe even in a greater Ratio*, than the *electrical Denſity*, of the electrical Atmoſphere *ſuperinduced.*

§ 342. Now, we are *not* to imagine, that any Body, of any kind, or of any magnitude whatever, can become either *abſolutely* and compleatly *negative*, or *abſolutely* and compleatly *poſitive*; but, only *negative* or *poſitive*, in a *comparative* Degree. That is to ſay, that a Body may contain *leſs*, or may contain *more*, than its *natural* ſhare of Electricity: but that, *no* Body can, by any means we are acquainted with, be entirely *emptied* of its electrical Fluid, or be entirely *filled* with Electricity.

§ 343. Therefore, let $\frac{1}{mu}$ Part of the *natural ſhare* of Electricity, of any *given* Body *a* (for example,) denote the Quantity of *plus*, or the Quantity of *minus* Electricity, that the ſaid *given* Body *a* ſhall be able to acquire, by being immerged, to any *given* Degree, into the *given electrical Atmoſphere* of any *given* Prime-Conductor.

§ 344.

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† There is *not* the ſmalleſt doubt, but that the ſenſible Part of the *electrical Atmoſphere of a Thunder-Cloud* powerfully charged, does often extend *ſeveral Miles:* whereas, the ſenſible Part of the *electrical Atmoſphere of an electrified Prime-Conductor*, extends only *ſome feet.*

§ 344. Then, if the *given* Body *a* be immerged into the electrical Atmoſphere of any Thunder-Cloud, the *electrical Denſity* of which *electrical Atmoſphere* is *n* Times as great as the *electrical Denſity* of the *electrical Atmoſphere* of the above-mentioned given Prime-Conductor; it is evident, that the *Quantity* of *plus*, or the *Quantity* of *minus*, Electricity, that the *given* Body *a* would acquire, by being thus immerged into the *electrical Atmoſphere* of the Thunder-Cloud, would be expreſt by a Quantity *at leaſt* as great, as $\frac{1}{m}$ part of the *natural* ſhare of Electricity of that *given* Body *a*. I ſay, *at leaſt as great*; becauſe, it cannot ever be *leſs*, but (from Principles perfectly ſimilar to thoſe mentioned above †) it may be *greater*.

That is to ſay, that it would be expreſt by a number *at leaſt n* Times as great, as that, which would denote the Quantity of *plus*, or the Quantity of *minus*, Electricity, that the *given* Body *a* would acquire by being immerged into the *electrical Atmoſphere* of the *given* Prime-Conductor mentioned above (in § 343).

§ 345. Now, ſince the ſtrength of any electrical *returning Stroke* in any *given* Body *a*, is proportional to the Quantity of *plus*, or to the Quantity of *minus*, Electricity, that the *given* Body *a* would (by being immerged into any *electrical Atmoſphere*) be able to acquire; it moſt evidently

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† See § 341.

evidently follows, that *any returning Stroke*, which might be produced by an Exploſion taking place from the *Thunder-Cloud* mentioned above (§ 344), muſt be [*at leaſt*] *n* Times *more conſiderable*, than the *returning Stroke* which might, under *ſimilar* circumſtances, be produced by an Exploſion taking place from the *given Prime-Conductor* juſt-mentioned.

§ 346. But, ſince, the *electrical Denſity* of the electrical Atmoſphere of a *Thunder-Cloud*, is ſo *immenſe*, when compared to the *electrical Denſity* of the electrical Atmoſphere of any *Prime-Conductor*, charged by means of any electrical *Apparatus* whatſoever; and ſince, a *returning Stroke*, when produced by the *ſudden* Removal of even the *weak* elaſtick electrical *Preſſure* of the electrical Atmoſphere of a charged *Prime-Conductor*, may be extremely *ſtrong*, as we have ſeen above in PART X: it is mathematically evident, that, when a *returning Stroke* comes to be produced by the *ſudden* Removal of the very *ſtrong* elaſtick electrical *Preſſure* of the electrical Atmoſphere of a *Thunder-Cloud* powerfully charged; the *ſtrength* of ſuch a *returning Stroke* muſt be moſt *enormous*.

§ 347. Conſequently, there cannot be the ſhadow of a doubt, that, not only *Perſons* and *Animals* may be killed, but that particular Parts of *Buildings* may be very conſiderably damaged, by ſuch a powerful kind of electrical *returning Stroke*; even were it to happen at a *vaſt Diſtance* from the *Place where the Lightning falls*.

And it will be the more eaſy to underſtand, how ſuch very *powerful Effects* may be produced by an electrical *returning Stroke*, if we recall to our remembrance what has been related, in the foregoing Pages, with regard to the *force* and *pungency* of the *returning Stroke*, and with regard to the *exact ſimilarity* that there is, between the *ſenſation* produced by the *returning Stroke*, and the *ſenſation* produced by the (well-known, yet) tremendous *Leyden ſhock*. But, of theſe things, more will be ſaid hereafter.

P A R T XII.

SECTION 348.

THE account I have given, in the foregoing Pages, of the *Manner*, in which *particular Parts* of Buildings may be damaged, and in which *Perſons* and *Animals* may be deſtroyed, by Effects reſulting from electrical Exploſions that take place even at a *vaſt Diſtance*, muſt undoubtedly appear not a little ſingular. But, it will appear ſtill more ſingular, that *high metallick conducting Rods*, *acutely pointed*, will tend to ſecure effectually both Perſons and Buildings, againſt the various Effects of any *returning Stroke* whatever.

§ 349. It will be proper to begin by ſhewing in what Manner, *high* and *pointed conducting Rods* tend to prevent accidents, that might reſult from thoſe natural *electrical Cauſes* with which the World is already acquainted. I ſhall then proceed to evince the *univerſal* utility and *incomparable* advantage of ſuch *high and pointed* Conductors.

But, in order to do any of theſe things, it will be neceſſary, *firſt* to examine the Manner, in which, Conductors, of *different Terminations*, act upon the *electrical*

Fluid contained in any electrical Atmoſphere *ſuperinduced.*

§ 350. It is a vulgar Error (which ſome Perſons have induſtriouſly endeavoured to confirm), that *prominent metallick Points* ATTRACT the Matter of Lightning, and that *rounded Ends*, *Knobs*, and *Balls* do *not*. But, I hope I ſhall be able preſently to prove, that there is not a ſhadow of foundation for this opinion relative to *Points.*

§ 351. We muſt here diſtinguiſh *two caſes*; namely, 1*ſt*. The Attraction of the *electrical Matter* from a Thunder-Cloud, to different kinds of metallick Conductors. And 2*ndly*. The Attraction of the *Body of the charged Cloud* itſelf, towards ſuch Conductors reſpectively.

§ 352. With regard to the *firſt* of theſe caſes; *viz.* the *Attraction* of the *electrical Matter* from the Clouds to metallick Conductors, I think it will *not* be difficult to ſhew, that, neither *Points*, nor *rounded Ends*, have (properly ſpeaking) any *ſuch kind of Attraction* at all.

§ 353. The *apparent Attraction* that there is, in *prominent Conductors acutely pointed*, proceeds only from the *ſmall Degree of Reſiſtance* that Conductors with ſuch Terminations, oppoſe to the *Entrance* or to the *Exit*, of the electrical Fluid; as I ſhall fully explain, in the following Pages.

§ 354. For when a Thunder-Cloud approaches towards the Earth, its *electrical Atmoſphere* preſſes upon all the

Bodies that lie within a great Diſtance from it; and it preſſes the moſt ſtrongly upon thoſe Bodies, that are the neareſt to it: the *Denſity* of the Electricity, of electrical Atmoſpheres, being (as I have above moſt fully demonſtrated) in the *inverſe Ratio of the ſquare of the Diſtance.*

§ 355. Now, if theſe elevated Bodies, placed upon the Surface of the Earth, either be, in their nature, *bad Conductors* of Electricity; or good Conductors, with *ſuch Terminations* as tend ſtrongly to *reſiſt* the Entrance of the electrical Fluid, ſuch as *Balls or rounded Ends*: then, the weak Preſſure, of the Skirts of the Cloud's electrical Atmoſphere, will *not* be able to force any ſenſible Portion of electrical Fluid, into, or through, ſuch Conductors.

§ 356. Whereas, if any of thoſe Bodies, placed upon the Surface of the Earth, be a good *Conductor* of Electricity, terminated at its upper Extremity, in a *prominent and acute metallick Point*: then, the ſmalleſt Preſſure, of the Cloud's electrical Atmoſphere, will be able to cauſe *ſome Electricity* to paſs through ſuch a Conductor; the Extremity of which, does *not tend to reſiſt* (either by its *ſhape*, or by the *ſubſtance* of which it is made,) the free *Entrance* of the electrical Fluid.

§ 357. I have above † fully explained the reaſons why *prominent metallick Points*, connected with a conducting

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† § 42, § 43 and § 44.

-ducting Body electrified *in minus*, oppoſe but a very *feeble Reſiſtance* to the *Entrance* of the electrical Fluid *into* the conducting Body to which thoſe *Points* are properly connected. I have fully explained † alſo the reaſons why *prominent metallick Points*, connected with a conducting Body electrified *in plus*, oppoſe but a very *feeble Reſiſtance* to the *Exit* of the electrical Fluid *from* the conducting Body to which they are properly connected.

§ 358. Now, I have ſhewn above (§ 72), that every and § 182 *conducting Body*, which is placed within the ſenſible Part of any electrical Atmoſphere (whether that Atmoſphere be charged *in plus* or *in minus*), will neceſſarily tend to become charged, at its End (or Side) which is the *neareſt* to the charged Body producing that Atmoſphere, with an Electricity *contrary* to that of the electrical Atmoſphere in which it is immerged.

§ 359. Therefore, if an *elevated Conductor* be placed upon the Surface of the Earth, and if it be within the *ſenſible Part* of a *poſitive* Thunder-Cloud's electrical Atmoſphere (which it muſt neceſſarily be, long before it can come within the *ſtriking Diſtance* of that Cloud); then it is evident, that the upper Extremity of ſuch a Conductor will (according to the *Law* laid down above § 358) become *negative*.

§ 360.

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† § 34, § 35 and § 36.

§ 360. Conſequently, if the *upper Extremity* of this Conductor, be armed with a *prominent acute metallick Point*; that *Point*, by being fixed to a *negative* Body will (according to the Rule alluded-to above § 357) oppoſe but a very *feeble Reſiſtance to the Entrance* of the Electricity of the Cloud's electrical Atmoſphere *ſuperinduced.*

§ 361. In like manner, if the Cloud's electrical Atmoſphere be *negative*; the *upper Extremity* of the elevated Conductor will become *poſitive*; and the *prominent acute metallick Point*, in which it is terminated, will oppoſe but a very *feeble Reſiſtance, to the Exit* of the Electricity of the Rod, and to the *Exit* of the Electricity of the *common ſtock* to which the Rod is properly connected.

§ 362. Now, in order the more clearly to explain in what manner, a metallick *conducting Rod* acts upon the *electrical Fluid* that is contained in the electrical Atmoſphere which is *ſuperinduced* upon the upper Extremity of ſuch a Rod; it is neceſſary to premiſe, that a *metallick Rod* is a *Conductor* of the electrical Fluid, ſomewhat in the ſame manner, as an *hollow Pipe* is a *Conductor* of Water; tho' differing in the following reſpects.

§ 363. When Water runs through a *Tube*, it paſſes through its *cavity.* Whereas, it is the nature of the *electrical Fluid* to paſs through the very † *ſubſtance of a metallick Conductor*.

In this reſpect, *Electricity* reſembles *Heat*, which paſſes alſo through the *ſubſtance of Metals*.

§ 364. Again, when *Water* runs into an *hollow Pipe*, it is obliged to paſs through the *whole length* of the Tube, before any of the Fluid can run out at the *remote End*. Whereas, whenever any of the *electrical Fluid* is made to enter at one End of a *metallick Rod*, it will tend, at the *ſame inſtant*, to force an *equal Quantity* of Electricity, out at the remote End of that Rod; and *vice verſa*: the Rod containing, at all Times, a certain Quantity of electrical Fluid, which (by any Motion given to it, at one End of the Rod) will be *all* put in motion, ſenſibly at the *ſame* Time; as is moſt judiciouſly explained by Dr. *Franklin*, in his anſwer †† to *J. A. Eſq. of New York*.

§ 365. In order to underſtand diſtinctly, by means of a compariſon, the manner in which the *electrical Fluid* acts; let us ſuppoſe a Tube *open at both Ends*, and containing its *natural* Quantity of common *Air*. Now, it is evident, if any *Air* be forced *in* [or be forced *out*] at *either* End of the Tube; that then, an *equal* Quantity of

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† When I here make uſe of the Word *ſubſtance*, I would be always underſtood to ſpeak of the *phyſical Pores* of Bodies, in contradiſtinction to the *mechanical Pores*.

†† See the Page 290 of Dr. *Franklin's* Philoſophical Papers.
514

Air will run *out* [or will run *in*] at the *other* End; ſenſibly at the *ſame* Time.

Juſt ſo, will the *electrical Fluid* run *out* [or run *in*] at the End of a metallick conducting Rod which communicates with the common ſtock; whenever any electrical Fluid be forced *in* [or be forced *out*] at the *other* End of the Rod.

§ 366. Now, the manner, in which, a *metallick Rod*, properly connected with the *Earth*, and terminated at its upper Extremity in a *prominent acute metallick Point*, tends *gradually* and *peaceably* to convey to the Earth, the *Matter of Lightning* from any Thunder-Clouds *electrical Atmoſphere* in which it is immerged; bears much *ſimilitude* to the manner, in which, an *hollow Pipe*, that is *open at its upper Extremity* as well as at its *lower* End, does tend *gradually* and *peaceably* to convey to the Earth, any *rain-Water* that might gradually *flow* towards the Orifice at the upper Extremity of ſuch a Water Pipe.

§ 367. And no Perſon can be conſidered as having a juſt and true idea, of the *Manner* in which *pointed Conductors* act, who looks upon a *pointed conducting Rod* in any *other light*, than as an HOLLOW PIPE that permits the electrical Fluid *to enter*, *with facility*, *into its* [*pointed*] UPPER END, as faſt as any ſuch electrical Fluid is able gradually to flow towards it.

This action may be *negative*, as well as *poſitive*.

§ 368. It is moſt evident, that it is for the *two* following ſimple reaſons, that a wide hollow *Water-Pipe* is able *gradually*

gradually and *peaceably* to diſcharge any *rain-Water*, that might *flow* towards its *upper* Extremity.

1*ſt*. Becauſe, the Fluid is able *to enter*, into the Orifice at the *upper* End of the Pipe, *with facility*.

And 2*ndly*. Becauſe, the Fluid (after having entered) is able *to run out* at the *lower* End of the hollow Pipe, *as faſt* as it did *run in* at its *upper* Extremity.

§ 369. Now, for theſe two very *ſame* ſimple reaſons, it is, that *an high and pointed metallick conducting Rod, properly connected with the Earth*, is able *gradually* and *peaceably* (which is commonly called, in electrical phraſe-ology, *ſilently*) to diſcharge any *electrical Fluid*, that might be conveyed to its *upper* Extremity, by the *ſuper-induced electrical Atmoſphere*, of a Thunder-Cloud, or of any other charged Body whatever.

1*ſt*. Becauſe, the electrical Fluid, for reaſons fully explained † above, is able *to enter*, with *facility*, into the *upper* End of the Rod, which, by being very *promi-nent and pointed*, can oppoſe but a very *feeble Reſiſtance* to the *Entrance* of the Electricity, of the *electrical Atmoſphere* ſuperinduced.

And 2*ndly*. Becauſe, the electrical Fluid (after having entered) is able *to run out* at the *lower* End of the metal-lick conducting Rod, *as faſt* as it did *run in* at its *upper*

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† § 42, § 43 and § 44; alſo § ~~[illegible]~~ 357, § 358, § 359 and § 360.

N. B. If the Cloud's *electrical Atmoſphere* be ſuppoſed to be *negative* (inſtead of *poſitive*); then, a *ſimilar* proof will be made out, by making uſe of what was ſaid, in § 34 § 35 and § 36; alſo in § 357, § 358 and § 36[illegible].

Extremity: the *lower* End of the metallick Rod, being (as was juſt ſuppoſed) properly *connected* with the common ſtock.

§ 370. Now, *if* it would (as every Man of common ſenſe will allow) be abſurd to ſay, that the *hollow Water Pipe*, open at its *upper End*, *attracts*, *ſolicits* or *invites* the *Rain*, from the Clouds; becauſe, this *hollow Pipe* is able *to carry off freely* as much of the *Rain-Water*, as might flow ſucceſſively towards its *upper* Extremity: no leſs abſurd would it be to ſay, that a *metallick conducting Rod* placed upon the Surface of ‸the Earth, and terminated at its upper End in a *prominent acute metallick Point*, does *invite*, *ſolicit* or *attract* the *electrical Fire*, *or Matter of Lightning*, from the Clouds; becauſe, this *pointed Conductor* is (in like manner) able *to carry off freely* as much of the *electrical Fluid*, from the Cloud's electrical Atmoſphere ſuperinduced, as might flow ſuceſſively towards its *upper Extremity*.

§ 371. I well know, that Dr. *Franklin* and ſeveral other learned Electricians have made uſe of the *Expreſſion*, of a *Point* ATTRACTING *the electrical Fluid*; in order, to expreſs by a *ſingle* Word, a *known Effect*; but without *aſſerting*, that the *ſilent Diſcharge* through a *Point* was cauſed by any particular *Virtue of Attraction*.

Juſt ſo, Dr. *Maſkelyne* or Mr. *de la Lande* might very well ſay, that the SUN RISES: but, no Man could be ſenſeleſs enough to imagine, that thoſe great Aſtronomers were *really* of opinion, that the *Sun does actually riſe*, when the diurnal Revolution of the Earth makes it *appear* to do ſo.

372. I do *not* however abſolutely object to any Perſon's uſing, for *ſhortneſs* ſake, the Expreſſion of a *Point* ATTRACTING *the electrical Fluid:* tho' I ſhould myſelf rather wiſh to make uſe always of ſome *leſs ambiguous* Expreſſion. Therefore, what I have here ſaid, relative to there being *no real Attraction* in metallick *Points*, muſt be underſtood to refer to the ſyſtems only of *thoſe* Men, who moſt inconſiderately aſſert, that *prominent, ſharp metallick Points*, placed upon the *Surface of the Earth*, do, in reality and in fact, *invite, ſolicit and attract the Matter of Lightning from the Clouds*; and who, in conſequence of this falſe and moſt abſurd Hypotheſis, very unphiloſophically and ignorantly conclude, that *elevated Conductors, with acute metallick Points, are dangerous* to the Buildings upon which they are erected.

§ 373. Now, in order clearly to explain the great and *eſſential difference* that there is, between a metallick conducting Rod terminated at its upper Extremity in a *Ball* or *rounded End*, and a Conductor terminated at its upper Extremity in a *prominent acute Point* (ſuppoſing both Conductors to be properly *connected with the common ſtock*); it is neceſſary to conſider what conſequences muſt follow, from the Principles that have been laid down in the foregoing Pages.

§ 374. We have ſeen above (§ 358 and § 359), if a Thunder-Cloud be *poſitive*; that, the *upper* Extremity of any conducting Rod, which is within the ſenſible Part of the Thunder-Cloud's *electrical Atmoſphere*, will be *negative*.

§ 375. We have alſo ſeen above †, if a *negative* Body (ſuch as a conducting Rod, properly connected with the Earth, and immerged in the electrical Atmoſphere of a *poſitive* Thunder-Cloud) be terminated in a *Ball* or *rounded End*; that, a *great Degree of Reſiſtance* will be oppoſed to the *Entrance* of the electrical Fluid.

§ 376. Conſequently, a metallick conducting Rod terminated, at its upper Extremity, in a *Ball* or *rounded End*, will *not* be able (except in a very *ſmall* Degree,) to diſcharge *peaceably*, *gradually* and *ſilently* into the Earth, any of the electrical Fluid contained in the *electrical* †† *Atmoſphere ſuperinduced*.

§ 377. Therefore, if the *electrical Fluid* contained in the electrical Atmoſphere of an approaching Thunder Cloud, be prevented, by the *Ball* or *rounded End*, from diſcharging itſelf *gradually* and *ſilently* into the Earth, through the conducting Rod ſo terminated; it is evident, that, that *electrical Fluid* will be forced to *accumulate*. That is to ſay, that it will (as the Cloud approaches) increaſe *in denſity*, in the electrical *Atmoſphere* which is *ſuperinduced* upon the *rounded End* of the Conductor.

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† § 39, § 40 and § 41; alſo § 45 and § 46.

†† If the Clouds *electrical Atmoſphere* be ſuppoſed to be *negative* (inſtead of *poſitive*); then, a *ſimilar* proof will be made out, by making uſe of what
358 was ſaid, in § ~~361~~, in the beginning of § 36[illegible], in § 31, § 32 and § 33; alſo in § 37 and § 38.

§ 378. Now, it is evident, that the *greater the Ball* or *rounded End* is, by which the conducting Rod is terminated at its upper Extremity; the greater will the *Reſiſtance* be, which is oppoſed, at the upper Extremity of the Conductor, to the *Entrance* of the *ſuperinduced* electrical Fluid.

§ 379. The *greater the Reſiſtance is*, which is oppoſed, at the upper Extremity of the conducting Rod, to the *Entrance* of the *ſuperinduced* electrical Fluid; the ſmaller will the *Quantity of that Fluid* be, that can *gradually* and *ſilently* diſcharge itſelf, into the Earth, through the Rod, from the Thunder-Cloud's *electrical Atmoſphere ſuperinduced.*

§ 380. The *ſmaller the Quantity of electrical Fluid* is, that can be *ſilently* and *gradually* diſcharged, from the *ſuperinduced* electrical Atmoſphere, in a given Time; the greater will the *Denſity of the electrical Fluid* be, that does remain behind in the ſaid electrical Atmoſphere which is *ſuperinduced* upon the upper End of the metallick conducting Rod.

§ 381. And the *greater the Denſity of the Electricity* is, which is contained in the Thunder-Cloud's *electrical Atmoſphere ſuperinduced*; the greater will the *danger* be, of that electrical Atmoſphere *ſuperinduced* becoming, to any *given* Diſtance, a *ſudden Conductor* of the electrical *Charge* of the Cloud itſelf; according to the Principles laid down above (§ 28 and § 29).

Conſequently, the greater alſo will the *Diſtance* be, at which, ſuch an Effect will be able to take place.

§ 382. The real and true Effect, therefore, of a *Ball* or *rounded End*, placed at the upper Extremity of a metallick conducting Rod, is, to prevent (for reaſons already fully explained) the *electrical Fluid*, contained in the *electrical Atmoſphere which is ſuperinduced upon that upper End of the Conductor*, from diſcharging itſelf *gradually*, *peaceably* and *in ſilence*, through the Rod, into the Earth.

That is to ſay, that the Effect, of the *Ball* or *rounded End* placed at the upper Extremity of the metallick Conductor, is, to prevent the *electrical Atmoſphere ſuperinduced* from diſcharging its *electrical Fire*, or *Matter of Lightning*, into the Earth, UNTIL that *ſuperinduced electrical Fire* becomes, by the approach of the Thunder Cloud, conſiderably more *denſe*, conſiderably more *powerful* and more *dangerous*, and capable of producing (in the manner ſtated above, in § 29) a violent *main Exploſion*.

§ 383. So that, a *Ball*, or any *round kind of Body*, will, by being placed upon the *upper Extremity* of a metallick conducting Rod, neceſſarily tend, in a *very conſiderable* Degree, to *prevent* the *principal* good Effects of that Conductor of Electricity; and will, conſequently, tend alſo, in a *very conſiderable* Degree, *to deſtroy that admirable ſecurity*, which, as I ſhall fully demonſtrate hereafter, would conſtantly be effectually derived from that *conducting Rod*, if (at the Time that its *lower End* was properly *connected* with the Earth) its *upper Extremity* were to be terminated in a very *prominent* and *acute* metallick *Point*.

T PART XIII.

PART XIII.

SECTION 384.

HAVING fully explained, in the foregoing (†) Pages, HOW metallick *conducting Rods*, with *different terminations*, act upon the *electrical Fluid*, that is contained in the *electrical Atmoſphere* which is *ſuperinduced* upon the upper Extremity of ſuch Rods *reſpectively*: and having likewiſe explained (††) *what the* REASON *is*, for which, *conducting Rods*, with ſuch *reſpective terminations*, do act in the particular *Ways* above-ſpecified: I ſhall now proceed to explain *what the* MANNER *is*, in which, *high metallick conducting Rods*, *acutely pointed*, and properly erected, will tend to *ſecure* both Perſons and Buildings, againſt All accidents whatever that could reſult from Lightning; and alſo to ſhew, WHY *Conductors*, terminated in *Balls* or *rounded Ends*, do *not* tend to give, by any means, the ſame admirable Degree of *ſecurity*, againſt any of the *various* fatal Effects which may reſult from natural Electricity.

(†) In PART XII.

(††) From § 30 to § 49; and alſo in PART XII.

§ 385. There are *three ways*, in which Damage may be done by Lightning; namely,

Firſt, by the Matter of Lightning (in its deſcent from a Thunder-Cloud to the Earth), paſſing immediately through a Body, or immediately over its Surface.

This is called the *main Stroke*; and it may be *negative*, as well *as poſitive*.

The *main Stroke* may, either be *direct*, that is, it may proceed *immediately* from the *main Cloud* itſelf; or it may be *tranſmitted*, that is to ſay, it may be conveyed to the Earth, through one, or more *intermediate*, or *ſecondary* Clouds; as will be fully explained hereafter.

§ 386. Secondly, Damage may be done by Lightning; by ſome Part, of the electrical Fire, which paſſes through a Conductor, *ſuddenly entering* into a Body (placed in the *Vicinity* of ſuch electrical Circuit), and *inſtantly paſſing out again*; as is admirably explained by Dr. *Prieſtley*, in that moſt excellent Paper which is publiſhed in the *Sixtieth Volume* (†) of the *Philoſophical Tranſactions*, where he ſays; that, "this Effect is ſimilar "to a *partial Circuit*, in which, Part of the electric Matter, "that forms the *Charge* in an Exploſion, goes *one way*, "whilſt the reſt of the Charge *goes another*: the only "difference is, that this detached Part of the Charge leaves "the common Track, and *returns to it again in the* "*very ſame Place*."

(†) See Page $\frac{192}{567}$ & *ſeq*.

This is called the *lateral Exploſion*; and it muſt, in its very nature, be always *both poſitive and negative*, ſenſibly at the *ſame* inſtant. But, any *unelectrified* conducting Body, that receives a *lateral Exploſion*, may (if inſulated) remain, after ſuch *Exploſion*, either electrified *in plus*, electrified *in minus*, or *not electrified at all*; according to the poſition of the inſulated Body, and according to the particular circumſtances attending the *lateral Exploſion*.

§ 387. And Thirdly, Damage may be done by Lightning; by the *ſudden violent Return*, *of that Part* of the natural ſhare of Electricity [of any conducting Body, or of any combination of conducting Bodies], which had been *gradually* expelled (from ſuch Body or Bodies reſpectively), by the *ſuperinduced* elaſtick electrical *Preſſure* of a Thunder-Cloud's electrical Atmoſphere.

This I call the *returning Stroke*; and it may be *negative*, as well as *poſitive*.

§ 388. The *Manner*, in which I conceive, that a metallick *conducting Rod*, properly connected with the Earth, and terminated at its upper Extremity in a *prominent and acute metallick Point*, tends to ſecure *that Part* of the Edifice, upon which it is erected, againſt any *direct main Stroke of Exploſion*; is as follows.

§ 389. We have ſeen above (§ 369), that *an high and pointed metallick conducting Rod*, *properly connected with the Earth*, will be able *gradually*, *peaceably*, and *ſilently* to diſcharge any *Electricity*, that might be conveyed to its upper Extremity, by the *ſuperinduced electrical Atmoſphere* of a Thunder-Cloud.

That, is to ſay, that an *high and pointed Conductor* will *ſilently diſcharge* into the Earth, *the Electricity*; of *that Part* of the charged Atmoſphere, into which, its upper Extremity is *particularly* immerged; and muſt, of courſe, leave *that Part* of the electrical Atmoſphere, *deprived of Electricity*.

§ 390. We have alſo ſeen above (in § 28 and § 29), that, it is the *Electricity*, contained in an electrical Atmoſphere, which cauſes that *electrical Atmoſphere* to become a *ſudden Conductor* of the *electrical Charge*, to a *given Diſtance* from the charged Body producing that electrical Atmoſphere.

That is to ſay, in other words, that the *ſtriking Diſtance* of any Thunder-Cloud, is always *produced by the Electricity*, which is *contained in the electrical Atmoſphere* of that Thunder-Cloud.

§ 391. Now,

1*ſt*. Since, *the Exiſtence of an Effect*, which could never be produced but by the *immediate Operation of a given Cauſe*, muſt always, of neceſſity, *be prevented from taking place*, by the *Removal of ſuch given Cauſe*:

2*dly*. Since, the *ſtriking Diſtance* of any Thunder-Cloud, is (as was ſaid above § 390) always *produced*, *by the Electricity*, *which is contained in the electrical Atmoſphere* of that Thunder-Cloud:

And 3*rdly*. Since, an *elevated and acutely pointed Conductor*, properly erected, does (as I have ſhewn above, § 389) *diſcharge*, into the Earth, the *Electricity*, of *that Part* of an electrical Atmoſphere, into which, it is *particularly* immerged:

It evidently follows, that, an *elevated and acutely pointed conducting Rod cannot ever* (under ſuch circumſtances) *be within the* STRIKING DISTANCE of the Thunder-Cloud, which produces the *electrical Atmoſphere*, that is thus *ſuperinduced* upon the upper Extremity of ſuch an *high and pointed Conductor*.

§ 392. But it is evident, that *this* would *not* be the caſe, if the upper Extremity of the conducting Rod, were to be terminated (*not* in a *prominent acute Point*, but,) in a *Ball* or *rounded End*; particularly, if the Degree of *Prominency*, of the upper Extremity of the Conductor, were to be but ſmall.

§ 393. For, we have ſeen above (§ 376), that a *Ball* or *rounded End* does *not* tend (except in a very *ſmall* Degree) to diſcharge *peaceably*, *gradually* and *ſilently*, into the Earth, *any of the Electricity* contained in the *electrical Atmoſphere ſuperinduced*.

§ 394. Conſequently, it muſt plainly appear, from the important Principles laid down above (in § 390), that, a *Ball* or *rounded End*, placed at the upper Extremity of a metallick Conductor, will *not* be able to *decreaſe*, in any ſenſible Degree, the *ſtriking Diſtance* of a *Thunder Cloud*: ſince, every *ſtriking Diſtance* (that can exiſt, between any charged Body producing an electrical Atmoſphere, and any conducting Body therein immerged) can be produced, only by the *conducting Power, of the*

the electrical Fluid itſelf contained in the *electrical Atmoſphere* that is *ſuperinduced* upon the Conductor.

§ 395. That is to ſay, in other words, that a *Ball* or *rounded End* will *not* tend [in the admirable manner that a *prominent acute metallick Point* does] to ſecure *that Part* of a Building upon which it is erected, againſt any *direct main Stroke of Exploſion* from a Thunder-Cloud.

PART XIV.

PART XIV.

SECTION 396.

I Apprehend, that the *Manner*, in which an *elevated and acutely pointed* conducting Rod (properly erected) tends to ſecure a Building, againſt any *direct main Stroke of Exploſion*, is, in general, *That* which I have already ſo fully ſtated in SECTION 391: but, an *high and pointed* Conductor will tend to produce, that moſt ſalutary Effect, *alſo* in the following [not very unſimilar] manner; namely,

By diſcharging the Electricity, *not only of that Part, of a Thunder-Cloud's electrical Atmoſphere, into which, it is particularly immerged*; but likewiſe the Electricity of *other Parts* ſucceſſively, of ſuch electrical Atmoſphere.

§ 397. We have ſeen above (§ 389), that an *high and pointed* metallick Conductor will, by the operation of a *ſilent Diſcharge*, leave *that Part* of the electrical Atmoſphere, into which, it is *particularly* immerged, *deprived of Electricity*.

The conſequence of which muſt be, that the *Electricity* of the *other Parts* of this elaſtick electrical *Atmoſphere*, will *ſucceſſively flow* towards *that Part* of this Atmoſphere: in order, to ſupply the place of the Electricity, that had been ſo *diſcharged*. Which *Flux of Electricity* will, of neceſſity, cauſe the *Electricity* of the electrical Atmoſphere, *to become gradually more rarefied throughout*.

§ 398. Now, in order to illuſtrate the Manner, in which, the electrical Fluid is here decreaſed *in denſity*; let us ſuppoſe (for example) that, a Part of the *condenſed Air* in a condenſing Receiver, were to be permitted to *run out*, through any hole, made in the ſide of the Receiver.

The conſequence of this would be, that the *Remainder* of the condenſed Air, would *flow* to ſupply the place of that Air, which had thus been ſuffered to depart: whereby the *Air*, in the Receiver, would *become gradually more rarefied throughout*.

§ 399. But, the two following Differences between the reſpective tendencies of theſe two Fluids (*viz. Air* and *Electricity*), to an *atmoſpherical Equilibrium*, deſerves particular notice; namely,

1ſt. That, the *condenſed Air* in a [confined] Receiver tends to be *throughout*, ſenſibly of the *ſame Denſity*.

Whereas, the *electrical Fluid*, contained in an electrical Atmoſphere, tends always to be, with reſpect to *Denſity*, in the *inverſe Ratio of the ſquare* † *of the Diſtance* from the

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† This is ſuppoſing (what is, in reality, the caſe, in an *electrical Atmoſphere* of a *ſmall* extent), that, *the Denſity of the Air*, in the electrical Atmoſphere, is *ſenſibly of the ſame Denſity, throughout*. For, I am well aware of the variations that muſt neceſſarily ariſe, in the *general Law* above-mentioned, from *the Air* [conſtituting the *electrical Atmoſphere*] *decreaſing in Denſity*, in the *upper Parts* of the electrical Atmoſphere; in the Caſe, when ſuch *electrical Atmoſphere* is of a *vaſt* extent.

the charged Body which produces ſuch electrical Atmoſphere; as I have moſt fully demonſtrated above.

§ 400. And 2ndly. that, when any of the *Air*, in a condenſing Receiver, is ſuffered to run out, on any ſide; the *Remainder of the Air*, in the Receiver, will *flow almoſt inſtantly*, to ſupply its place.

Whereas, when any *electrical Fluid*, from any Part of an electrical Atmoſphere, is diſcharged into the Earth; the *Remainder of the electrical Fluid*, therein contained, will *flow*, only *gradually*, to ſupply its Place. Becauſe, an *electrical Atmoſphere* muſt, in its nature, always be, to a *given* Degree, a *non-conductor* of Electricity. For, if it were *not* (even, when there is much Moiſture in the *Air)*; it is evident, that the charged Body, producing ſuch electrical Atmoſphere, could *not*, for a moment, *retain its Charge*. Or, to ſpeak more properly, *no kind of Body*, immerged in an Atmoſphere, that was *not*, in a *given* Degree, a *non-conductor* of Electricity; *could receive any Charge at all*.

§ 401. Now, if the *Denſity of the Electricity* of any electrical Atmoſphere be *decreaſed*, in the manner mentioned above (§ 397); it is evident, from what has been laid down in the foregoing † Pages, that, the *ſtriking Diſtance*, of the charged Body producing that electrical Atmoſphere, muſt alſo become *leſs conſiderable*.

§ 402.

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† See § 390.

§ 402. That is to ſay, that (in the caſe before us), the action of *ſilent Diſcharge*, through a *prominent, acute metallick Point*, properly connected with the Common Stock, *will decreaſe the ſtriking Diſtance*, of the Thunder-Cloud, which produces the electrical Atmoſphere *ſuperinduced.*

§ 403. In order fully to explain the prodigious *Difference* that there is, in this *laſt-mentioned* reſpect, between the reſpective Actions of *Balls*, and of *acute prominent Points* [properly connected with the Common Stock]; let us ſuppoſe a Thunder-Cloud A, to move over the Surface EHK of the Earth, along any Line (for example) ALND. Fig. 17.

Let us ſuppoſe, that there be, upon any Building B, a metallick conducting Rod C [properly connected with the Common-Stock, and] terminated at its upper Extremity, in a *Ball* or *rounded End.*

And let us ſuppoſe, that the *Diſtance*, to which, the *electrical Fluid*, of the electrical Atmoſphere of the Thunder-Cloud A, will be able *ſuddenly to conduct* the *given Charge of Electricity* of that Cloud, be equal to the *given* Line AG. That is to ſay, let the *given* Line AG repreſent the *ſtriking Diſtance* of the electrified Cloud A, upon the *given rounded Termination* of the above-mentioned Conductor C.

§ 404. Then, it is evident, from what was ſaid above†, that the *Ball* or *rounded End* of the Conductor C, will

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† § 393.

not tend [during the Time that the Thunder-Cloud moves along the Line ALND] to *decreaſe*, in any very ſenſible Degree, the *Denſity* of the Electricity, of the electrical Atmoſphere *ſuperinduced*.

§ 405. Now, ſince, it is upon the *Denſity of the Electricity* contained in any electrical Atmoſphere, that the *ſtriking Diſtance*, of the charged Body which produces that electrical Atmoſphere, does depend; as we have ſeen † above: it evidently follows, that, in the caſe before us, the *Ball* or *rounded End* will *not* tend to *decreaſe*, in any very ſenſible Degree, the *ſtriking Diſtance* of the charged Cloud.

That is to ſay, in other words, that, the different *ſtriking Diſtances*, AG, LM, NO, DF, &c. of the Cloud A, taken at *different* Inſtants of Time, during the *Paſſage* of that Cloud, will be nearly *equal* to each other.

§ 406. Therefore the Line GMOF, &c. which repreſents the *Limit of the ſtriking Diſtance* of the Thunder Cloud, will be nearly *parallel* to the Line ALND, deſcribed by the Cloud itſelf.

§ 407. Conſequently, ſhould this Cloud, in its deſcent towards the Earth, paſs within the *given Diſtance* AG, (or LM, or NO, or DF, &c.) of the Building B: then, either the metal *Ball* at the upper End of the Conductor C, or the *Building* B *itſelf* upon which it is erected, will neceſſarily be *ſtruck* by the Lightning from the Cloud; as ſoon as that charged Cloud approaches near the Zenith of that Building. Becauſe, that Building will be *within the Line* GMOF, &c. which repreſents the *Limit of the ſtriking Diſtance* of that Cloud.

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† § 28, § 29 and § 399.

§ 408. Now, in order, to make the *Difference* between the reſpective actions of *Points* and *Balls*, in the caſe before us, the better underſtood; let us ſuppoſe a Thunder-Cloud *a* [*equal* and *ſimilar* to the Thunder Cloud A mentioned above, in § 403; and *equally* charged with the *ſame* kind of Electricity], to move with the *ſame Velocity* as the above-mentioned Cloud A, along any Line *a l n d*, over the Surface *e h k* of the Earth; and at the *ſame Diſtance* from it, as in the former caſe. Fig. 18

§ 409. Let us ſuppoſe alſo, that a Building *b* [*ſimilarly* ſituated to the Building B above mentioned,] be ſecured, by a very *elevated and acutely pointed* Conductor *c*, properly connected with the Common-Stock.

§ 410. It is evident, from our Hypotheſis mentioned above, in § 408; that the Line *ag* (in Figure 18) which is equal to the Line AG (in Figure 17;) will repreſent what the *ſtriking Diſtance* of the Cloud, is, before the *Denſity of the Electricity*, of the Cloud's electrical Atmoſphere, comes to be anywiſe affected, by the action of the *pointed* Conductor *c*, that is thus erected upon the Building *b*.

§ 411. Now, if *ca*, be the Diſtance from the Cloud, at which, the *prominent acute Point c*, will be able to begin, *ſilently* to carry off, any ſenſible Part of the *Electricity*, of the Cloud's electrical Atmoſphere; then, it is evident, that the *Charge of Electricity*, in the Cloud's electrical Atmoſphere, will be continually *decreaſing*, during the Time, that the Cloud, by moving along its *Path a d*, approaches gradually nearer to the *prominent acute Point*, of the metallick Conductor *c*.

§ 412. It is moreover evident, that the *nearer* the electrified Cloud *a*, comes to the Conductor *c*; the ſtronger will be, the *ſilent Diſcharge*, through the Point, from that Cloud's *electrical Atmoſphere*: ſince, the *ſuper-induced* elaſtick electrical preſſure of an electrical Atmoſphere, is (as I have fully demonſtrated above,) in the *inverſe Ratio of the ſquare of the Diſtance.*

§ 413. And the ſtronger, the *ſilent Diſcharge*, through the *Point*, is; the more the *electrical Charge*, in the Cloud's electrical Atmoſphere, will (thereby) be *diminiſhed*, *in a given Time.*

§ 414. Therefore, the Line, that will be deſcribed by the *Limit of the ſtriking Diſtance* of the Cloud, will *not* be, as in the former caſe, *parallel* (or nearly parallel) to the *Path of the Cloud*; but will be, a ſingular kind of *Curve* [as *g p r s q t*, in the Figure] continually approaching the *Path a d*, of the Cloud.

§ 415.

§ 415. The *ſilent Diſcharge*, through the metal Point *c*, being, at the beginning, neceſſarily *weak*; the *original ſtriking Diſtance a g*, of the Cloud, will be, at firſt, but very little diminiſhed.

The *firſt* Part, of the Curve, therefore, [ſuch as the Portion *g p*, for example] will nearly *coincide* with the Line *g m*, which is parallel to *a d*.

§ 416. The *nearer* the Cloud approaches, to the prominent Point, of the Conductor; the more, the *ſilent Diſcharge*, from the Cloud's electrical *Atmoſphere*, will increaſe.

Therefore, the *Curve*, [as from *p*, to *r*] will *diverge gradually*, ſtill more, from the Line *g o*, which is parallel to the *Path* of the Cloud.

§ 417. The Cloud, being arrived ſtill nearer, to the Zenith of the Conductor; the *ſilent Diſcharge*, from the Cloud's electrical Atmoſphere, will be powerfully increaſed.

Conſequently, the *Curve*, which is deſcribed, by *the Limit of the ſtriking Diſtance*, of this electrified Cloud, will [as from *r*, to *s*, in the Figure] fly quite off from the *pointed Conductor c*, and from the Building *b*, upon which it is erected.

§ 418. That is to ſay, that, by the pointed Conductor's action of *ſilent Diſcharge*; the Building, upon which ſuch Conductor is properly erected, will be ſecured againſt any *direct main ſtroke of Exploſion* from the Thunder Cloud.

§ 419.

§ 419. The *ſilent Diſcharge,* from the electrical Atmoſphere of the Cloud *a,* will continue, even after this Cloud, has paſſed the *Zenith* of the Conductor *c*: tho' the ſtrength, of the *ſilent Diſcharge,* will, as the Cloud moves off, *gradually decreaſe.*

The remaining Part *s q t,* of the *Curve,* will therefore, become *concave,* towards the Earth; as the other Portion *g p r s,* of this *Curve,* became *convex.*

§ 420. But, the *electrical Charge,* of the electrical Atmoſphere of the Cloud *a,* having, during the Time of the Cloud's Paſſage over the *pointed Conductor c,* been *diminiſhed*; it is evident, that the *ſilent Diſcharge,* through the *prominent Point,* will *ceaſe,* as ſoon as the Cloud gets to a *certain* Diſtance [ſuch, for example, as *c i,* in in the Figure,] from the Conductor *c*; which Diſtance will be *leſs* conſiderable, than the Diſtance *c a,* at which, this *pointed* Conductor, began (upon the approach of the Cloud) to carry off, in a *ſilent* manner, the *Electricity,* contained in the Cloud's electrical Atmoſphere *ſuper-induced.*

§ 421. To be able to determine, with preciſion, what the above-mentioned *Curve g p r s q t,* in any caſe, would be; it would be neceſſary, to have GIVEN, the *Charge of Electricity,* in the Thunder-Cloud's electrical Atmoſphere; the Degree of *prominency,* the Degree of *tapering,* and the Degree of *acuteneſs,* of the pointed Conductor; the Degree of perfection of the *conducting Power* of the Rod, &c. which forms the communication, between the metal Point and the Waters of the Earth;

the relative *Elevation* of the Cloud; the *Diſtance* of the Cloud from the Conductor, at the beginning of the ſenſible *ſilent Diſcharge*; the *Diſtance* of the Cloud, when it is the neareſt to the *Zenith* of the Conductor; the natural *electrical Denſity* of the Cloud's electrical Atmoſphere, at ſome *given* Diſtance from the Cloud; the elaſtick *electrical Preſſure*, *ſuperinduced*, at ſome *given* Inſtant, upon the Point; the original *ſtriking Diſtance* of the Cloud; the Degree of *Heat*, and the Degree of *Moiſture*, of the Atmoſphere; the *Denſity of the Air* that conſtitutes the electrical Atmoſphere *ſuperinduced*; the *Velocity* of the Cloud; the *Declination of* its Path, with reſpect to the Conductor *given in poſition*; and the *Inclination* of its Path, during its Paſſage over the Building.

§ 422. From theſe *Data*, either the *Equation*, or the *tranſcendental Nature*, of the above-mentioned *Curve*, deſcribed by the *Limit of the ſtriking Diſtance* of the Cloud, might, in any caſe [by making uſe of the above mentioned moſt important Theorem, of the *Denſity of electrical Atmoſpheres, being, in the inverſe Ratio of the ſquare of the Diſtance*], be, if required, properly computed.

§ 423. But, whatever be the Nature of this *Curve*; that is to ſay, whatever be the exact *Law*, according to which, an electrical *ſilent Diſcharge*, from a *given* Thunder Cloud's electrical Atmoſphere, tends to decreaſe the *ſtriking Diſtance* of that Cloud: *two* Things muſt, from what I have ſaid above, † appear perfectly evident; namely,

X. *1ſt.* That,

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† In PART XIII, and PART XIV; alſo, in PART XII.

1*ſt*. That, an *high and acutely pointed Conductor*, properly erected, muſt neceſſarily tend to *ſecure*, that Part of the Building to which it is affixed, againſt any *direct main Stroke of Exploſion* whatſoever from a Thunder Cloud.

And 2*ndly*. That, this moſt admirable *Effect* is produced, [*not* by the *pointed* Conductor *ſoliciting*, *inviting*, or *attracting* the Matter of Lightning from the Clouds; but,] merely, by the *prominent acute metallick Point*, of the Conductor, *diſcharging gradually*, *peaceably*, and *ſilently*, through the conducting Rod, into the Earth, *the Electricity*, *that is contained in*, *or that flows to*, THAT PART *of the electrical Atmoſphere*, *into which*, *that acute Point is* PARTICULARLY *immerged*.

PART XV.

PART XV.

SECTION 424.

IN the courſe of what I have above endeavoured to eſtabliſh, with regard to the *eſſential Difference* that there is, between the reſpective actions of *metal Balls* or *rounded Ends*, and of *prominent acute metallick Points*; I have ſaid, † that it was neceſſary, to diſtinguiſh *two caſes*; namely,

1*ſt*. The Attraction of the *electrical Matter* from a Thunder-Cloud, to different kinds of metallick Conductors.

And 2*ndly*. the Attraction of the *Body of the charged Cloud* itſelf, towards ſuch Conductors reſpectively.

Having ſpoke to the *firſt* of theſe Points; I will now ſay a few Words upon the *ſecond*.

§ 425. It is a Propoſition, univerſally true in Electricity, that, Bodies, charged with *different* kinds of Electricity, tend to *attract* †† each other, whenever their *oppoſitely electrified Atmoſpheres interfere*.

§ 426.

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† § 351. †† ſee § 22 and § 23.

426. Now, I have ſhewn above, † that all conducting Bodies, immerged in the *electrical Atmoſphere* of any charged Body, will, at their End, [or Side,] that is the *neareſt* to the charged Body, become charged with an Electricity, *contrary* to that of the charged Body producing that electrical Atmoſphere.

§ 427. Therefore, whenever any Thunder-Cloud [charged either *in plus* or *in minus*] paſſes over the Surface of the Earth; all *conducting* Bodies, which riſe above the Surface of the Earth, and which have *not* the property of carrying off *in ſilence* the electrical Fluid contained in the electrical Atmoſphere *ſuperinduced*; muſt, of neceſſity, become charged with the *contrary* Electricity to that of the Cloud; if they be within the ſenſible Part of the Cloud's electrical Atmoſphere.

§ 428. That is to ſay, that all *metallick Conductors*, for example, terminated in *Balls* or *rounded Ends*, muſt, (from what has been ſaid above, § 358, § 376, and § 427,) neceſſarily become *negative*, if the Cloud be *poſitive*; or *poſitive*, if the Cloud be *negatively* electrified.

§ 429. Conſequently, the Cloud will tend to attract *them*; and they will tend to attract the *Cloud*.

But, they being *immovable*, and the Cloud being ſuſceptible *of motion*; the Cloud will tend to move towards ſuch *Balls* or *rounded Ends*; and it will [when arrived ſufficiently near,] *ſuddenly diſcharge*, upon ſuch *blunted* Conductors, its Electricity, *with an Exploſion.*

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† See § 72.

§ 430. Thoſe excellent Experiments, with the *ſuſpended Prime-Conductor*, and with the *inſulated Pair of Scales* (invented by Dr. † *Franklin*); and the Experiment with the *electrified gilt* †† *Bladder* (invented by that ingenious Electrician the late Mr. *Henly*, F. R. S.) prove the Truth of this Propoſition moſt fully.

§ 431. Whereas, were the conducting Rods mentioned above (§ 428), to be terminated (*not* in *Balls*, or *rounded Ends*; but,) *in prominent acute metallick Points*; the *Cloud would not be attracted* by ſuch *pointed* Conductors; as the *ſecond* Parts of the above-mentioned Experiments, with the *ſuſpended Prime-Conductor*, with the *inſulated Pair of Scales*, and with the *electrified gilt Bladder*, clearly demonſtrate.

§ 432. The reaſon why a Thunder-Cloud *is not attracted* by an *high and acutely pointed* metallick Conductor [properly erected], is evident.

We have ſeen above (in § 389), that, a *prominent acute metallick Point* [properly connected with the Common Stock,] will *ſilently diſcharge*, into the Earth, *the Elec-* [illegible] *tricity*, [illegible]

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† See Dr. *Franklin's* Philoſophical Papers, Pages 62, 63 and 64.

514

†† See Mr. *Tiberius Cavalo's* compendious Treatiſe of Electricity, Pages 278 and 279.

404

-*tricity*, of *that Part* of a charged Atmoſphere, into which, it is *particularly* immerged; and will, of courſe, leave *that Part* of ſuch electrical Atmoſphere, *deprived of Electricity.*

That is to ſay, that the *prominent acute Point*, of a *pointed* Conductor [properly erected], will, by means of *its Action of ſilent Diſcharge*, come to be *no longer within the electrical Atmoſphere*, of a Thunder-Cloud.

§ 433. Therefore, the *Cloud* will *no longer be attracted* by ſuch a *Point*. Becauſe, (as was explained† above) Bodies charged with *different* kinds of Electricity, tend to *attract* each other, *only* in the Caſe, when their *oppoſitely electrified Atmoſpheres interfere.*

§ 434. *This* is *not*, however, the *only* reaſon, for which, certain Clouds would *not be attracted* by ſuch a *Point.*

§ 435. I have explained, in the foregoing †† Pages, that, by means of the electrical *ſilent Diſcharge*, through a Point; the *electrical Atmoſphere*, into which, the Point is immerged, will *gradually become more rarefied throughout.*

Now, we have moreover ſeen ††† above, that, it is the *electrical Atmoſphere*, which ſurrounds a charged Body (whether electrified *in minus*, or *in plus)* that cauſes ſuch charged Body to *retain its Charge.*

§ 436.

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† § 22, § 23 and § 425. †† § 397.

††† § 31, § 32 and § 33; alſo § 39, § 40 and § 41.

§ 436. Therefore, if [by the above-mentioned operation of a *Point*] the *electrical Denſity*, of the electrical Atmoſphere which ſurrounds the charged Body, *be gradually decreaſed*: it is evident, that, the *electrical Charge*, of ſuch charged Body, muſt be *retained*, in that Body, *leſs ſtrongly*; and muſt, of courſe, *gradually decreaſe*.

§ 437. It is for *this Reaſon*, that an electrified Prime Conductor becomes *diſcharged*, by the gradual approach of a *Point*; and *not* becauſe a metallick *Point* does (from a diſtance) *ſolicit*, *invite* and *attract* the Matter of Lightning *immediately out of ſuch charged Body itſelf*; as it has been moſt unphiloſophically imagined, and moſt abſurdly pretended.

§ 438. Now, it is evident, from theſe Principles, that *prominent*, *acute Points*, properly connected with the Common-Stock, will tend *gradually* and *peaceably* to convey to the Earth, the Electricity, *not only* from electrified *Prime-Conductors*, but from electrified *Clouds*; with the Difference (in the latter caſe,) of the *greater length of Time* of the *ſilent Diſcharge*, and of the *greater Quantity* of ſuch Diſcharge, in a *given* Time. Alſo that, electrified *Clouds*, of a moderate or ſmall ſize, will finally become *unelectrified* [or nearely unelectrified] by ſuch gradual operation of *ſilent Diſcharge*, through an *acute Point*, thus immerged in the electrical Atmoſphere of ſuch charged Clouds.

§ 439. Now, it is evident, that *ſuch Clouds*, as become thus *unelectrified*, can have *no electrical Attraction* towards the *pointed Conductor*.

But we have ſeen above (§ 432 and 433), that an *high and pointed* Conductor, will be able to *prevent a Thunder-Cloud from being attracted* towards ſuch *pointed* Conductor, even *without* its *unelectrifying* the Cloud itſelf; merely, by the Conductor diſcharging the Electricity, of *that Part* of the Cloud's electrical Atmoſphere, into which, the *prominent acute Point*, of ſuch Conductor, *is particularly* immerged.

§ 440. From the various Obſervations and Experiments, made in England, France, Italy, &c. and from thoſe, in particular, made by Mr. *De Romas*, it appears, that the *Quantity* of natural Electricity, which may *gradually*[†] *be* diſcharged, through metallick Bodies, into the Common Stock, may be enormous. Yet, as Mr. *De Romas*,[††] in his famous Experiments, made uſe of electrical *Kites*, raiſed to conſiderable heights above the Surface of the Earth; I wiſh [with reſpect to the Queſtion of common conducting Rods] *not* to lay quite ſo much ſtreſs upon thoſe Experiments, as they ſeem, in reality to deſerve.

§ 441. But Nothing, relative to the *gradual Diſcharge* of natural Electricity, through metallick Conductors, ever pleaſed me more, than the following *Fact* ✝ related by Dr. *Franklin*; becauſe, Nothing ever appeared to me, to be more directly to the purpoſe.

[†] Among other things, ſee the important Obſervation made by Captain *J. L. Winn*; Philoſophical Tranſactions, Volumn 60, Page 188 & ſeq.
567

[††] The Engliſh Electrician may find a very intereſting Account, of theſe Experiments of Mr. *De Romas*, in Dr. *Prieſtley's* excellent Hiſtory of Electricity; ſee Page 333 & ſeq.
712

§ 442. Dr. *Franklin* relates, that, in *Philadelphia*, he had a *pointed* conducting Rod, fixed to the top of his Chimney, and extending about *nine* feet above it. The Wire (which was about the thickneſs of a gooſe quill) paſſed through a covered Glaſs Tube in the Roof; and came down through the well of the ſtair-caſe. The lower End of the Wire, was connected with the iron ſpear of a pump. On the ſtair-caſe, oppoſite to Dr. *Franklin's* chamber door, there was an *interruption*, of about *ſix* inches, in this Wire; and a ſmall *Bell* was applied to the Wire, at each ſide of this interruption. A little *braſs Ball* was ſuſpended, by a ſilken thread, between theſe Bells; in order, for it to play between them, whenever any Clouds paſſed, that where charged with Electricity.

Dr. *Franklin* ſays, that he uſed frequently to draw ſparkes, and to charge bottles, from the Bell of the upper Wire; and he adds, that, one night, he was ſuddenly waked by *loud cracks* on the ſtair-caſe. Starting up, and opening the door, he perceived that the *braſs Ball*, inſtead of vibrating, as uſual, between the Bells, was repelled,

and

✝ See Dr. *Franklin's* Paper, entitled, *Experiments Obſervations and Facts tending to ſupport the opinion of the utility of* long pointed Rods, *for ſecuring Buildings from damage by Strokes of Lightning*:

A Tranſlation of this Paper is to be found in the French Edition of Dr. *Franklin's* Works, Volume the firſt, Pages 289 and 290.

338

The Original of this excellent Paper (together with other Papers of Dr. *Franklin*,) is about to be publiſhed, by Mr. *Johnſon*, Bookſeller, in St Paul's Church Yard.

and kept at a diſtance from both; during which time, the electrical Fire paſſed from Bell to Bell, ſometimes *in very large quick cracks*; and ſometimes *in a continued denſe white* † *ſtream, ſeemingly as large as one's finger*. Dr. *Franklin* moreover relates, that *the whole of the ſtair-caſe was, thereby, enlightened, as with ſunſhine*.

§ 443. Now, let us ſuppoſe, that, the *whole Quantity* of electrical Fluid, that Dr. *Franklin* ſaw thus running off, in a *continued ſtream*, during the Time of [perhaps] *ten* ^ were or *fifteen Minutes*, [illegible] to have been *all diſcharged on a ſudden, as*, for example, *in one tenth Part of a ſecond*, [or *leſs*] upon a Rod *without a Point*. Then, is it not evident, that the *Quantity* of Electricity, which did really paſs through Dr. *Franklin's high and pointed Conductor*, in any *tenth Part af a Second* [taken at an average], was, at leaſt, *ſix Thouſand Times leſs*, than ſuch *Quantity* of electrical Fire muſt have been, in the *ſame given Time* (of *one tenth Part of a Second*); had that Fire been diſcharged, *on a ſudden*, upon a Conductor, terminated in a *Ball* or *rounded End*?

What a prodigeous Advantage is this (among many others), of thoſe admirable Inſtruments, *high and pointed Conductors*!

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† Had this conducting Rod, of Dr. *Franklin*, *not* been thus conſiderably *interrupted*; it is evident, that the electrical *ſilent Diſcharge* (tho' it would *not* have been *viſible*,) would have commenced *ſooner*, would have been even *ſtill more compleat*, and would alſo have been of a *longer continuance*.

PART XV.I

PART XVI.

SECTION 444.

HAVING explained, in what Manner, *high and pointed Conductors*, tend to ſecure Buildings againſt any *direct main Stroke of Exploſion*, from a Thunder-Cloud; I will now proceed to ſhew, how, a *tranſmitted* † *main ſtroke of Exploſion* may alſo, by means of a *prominent, acute metallick Point*, be prevented from taking place *near* a conducting Rod, to which, ſuch an *acute Point* is affixed.

§ 445. There are *two* caſes, which, it is here, eſſentially neceſſary to diſtinguiſh; namely,

Firſt, that, the *intermediate*, or *ſecundary* Clouds, which ſerve to *tranſmit* to the Earth, any *main Stroke of Exploſion*, muſt either be ſo circumſtanced, as to *receive* Electricity, from the main Cloud, *with facility*.

Or, ſecondly, that they muſt be ſo circumſtanced, as *not* to receive Electricity, *with facility*, from the main Cloud.

§ 446. Now it is clear, with reſpect to the *firſt* of theſe caſes; that, *all* that has been ſaid, in the foregoing

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† See § 385.

Pages, relative to the *Manner*, in which, the electrical *ſilent Diſcharge* through a *prominent acute Point*, will be able to prevent any *direct main Stroke of Exploſion*; will be applicable alſo, to ſuch a *tranſmitted main Stroke of Exploſion*, as might proceed from any *intermediate* or *ſecundary* Clouds, ſo circumſtanced, as to *receive* Electricity, from the *main* Cloud, *with facility*.

For, it is evident, from what I have ſo fully laid down above, that, a *pointed Conductor*, properly erected, will *equally* produce a *ſilent Diſcharge*, of the *electrical Fluid*, that is contained in, or that flows to, *that Part* of the electrical Atmoſphere, into which, the *acute Point* is *particularly* immerged; whether, that *electrical Atmoſphere* be produced, by any ſet of *ſecundary* Clouds, that derive their Electricity, *with facility*, immediately from the *main* Cloud; or whether, that *electrical Atmoſphere* be produced by the *main Cloud* itſelf.

So that a *ſecundary* Cloud, that can receive Electricity, *with facility*, from a main Cloud, can only be conſidered as *a Part* † *of the main Cloud* itſelf.

§ 447. Therefore, the *only* Caſe, in which, a *tranſmitted main Stroke of Exploſion* can be conſidered, as *really* and *eſſentially differing* [as to its Effect,] from a *direct main Stroke of Exploſion*; is that caſe, in which, the *intermediate*, or *ſecundary Clouds*, that ſerve to *tranſmit* to the Earth, *a main Stroke of Exploſion*, are ſo circumſtanced, as *not* to receive Electricity, *with facility*, from the main Cloud.

§ 448.

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† See my Definition of a *ſingle* Thunder-Cloud, in the Note to § 312.

§ 448. Now, it is evident; that ſuch *intermediate*, or *ſecundary* Clouds, as here † mentioned, muſt be;

1*ſt*. Either *pending* to the under ſide of the main Cloud;

Or 2*dly*. *floating* [totally *independent* of the main Cloud,] between the main Cloud and the Earth.

§ 449. Firſt, let us conſider what muſt happen, if there be any ſmall Clouds *pending* to the under Side, of an electrified main Cloud.

§ 450. That excellent Experiment of the *electrified Lock of Cotton* (which was invented by Dr. *Franklin)* is ſo well known, that, I ſhould not enlarge upon it, in this place, were it not for the important conſiderations hereafter to be mentioned.

The following, are Dr. *Franklin*'s own words.

§ 451. " *Pointed Rods*, erected on Edifices may like-" -wiſe often *prevent a Stroke*, in the following manner."

" An Eye ſo ſituated as to view horizontally the under " Side of a Thunder-Cloud, will ſee it very *ragged*, with " a number of *ſeperate Fragments*, or *petty Clouds*, one " under another; the loweſt ſometimes not far from the " Earth. Theſe (as ſo many ſtepping Stones,) aſſiſt in " conducting a *Stroke* between a Cloud and a Building.— " To repreſent theſe, by an Experiment; take two or " three locks of fine looſe Cotton, connect one of them " with the Prime-Conductor, by a fine thread of two

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† § 447.

" inches (which may be ſpun out of the ſame lock by the " fingers), another to that, and the third to the ſecond, " by like threads.—Turn the Globe, and you will ſee " theſe locks *extend* themſelves towards the Table, (as " the lower ſmall Clouds do, towards the Earth,) being " attracted by it. But, on preſenting a *ſharp Point* erect " under the loweſt, it will ſhrink up to the ſecond, the " ſecond to the firſt, and all together to the Prime-Con-" -ductor; where they will continue, as long as the " *Point* remains under them."

" May not, in like manner," [continues Dr. *Franklin*] " the *ſmall electrified Clouds*, whoſe *Equilibrium* with " the Earth is ſoon reſtored by the *Point*, riſe up to the " *main Body*; and, by that means, occaſion ſo large a *Va-" -cancy*, as that the grand Cloud cannot ſtrike in *that* " *place*."

§ 452. This ſagacious *Suppoſition* of Dr. *Franklin* †, (contained in a Letter to *Peter Collinſon*, *Eſq*. F. R. S. dated September, 1753,) " Mr. *Wilcke* ††, in his Re-" -marks on Dr. *Franklin*'s Letters, ſays, that, on the " 20th of Auguſt 1758, he ſaw *verified*, as he was

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† See Dr. *Franklin*'s Philoſophical Works, Pages 134 and 135.
514.

This Experiment of the *electrified Lock of Cotton*, is alſo mentioned by Dr. Prieſtley, in his Hiſtory of Electricity, Pages 174 and 175; and by Mr.
712
Tiberius Cavallo, in his Treatiſe of Electricity, Pages 277 and 278.
404

†† See Dr. *Prieſtley*'s Hiſtory of Electricity, Page 175.
712

" viewing a *large fringed Cloud*, ſtrongly electrified,
" paſſing over a Forreſt of *tall Fir Trees.* The *ragged*
" *and depending Parts* of the large Cloud, were firſt *at-*
" *-tracted* lower, and then *ſuddenly roſe higher*, and joined
" the large Cloud."

A Philoſophical *Suppoſition*, more ſpeedily, and more reſpectably verified, by a natural *Phenomenon* of ſuch conſequence, is not, I ſuppoſe, to be met with, in the Hiſtory of the World.

453. I lay the greater ſtreſs, upon the above-mentioned Experiment, of the *electrified Lock of Cotton*; becauſe, it appears to me, to be one of thoſe, that have the greateſt Reſemblance *to what exiſts in nature*, at the Time of a Thunder-Storm.

Nay, I ſhould apprehend, that it *ſeldom*, or *ever* happens, that, an electrified *main Cloud* comes within a *ſtriking Diſtance* of the Earth; without there being *previouſly* formed, to its *under ſide*, ſome of the above-mentioned kind of ſmall *ragged, pending Clouds.* Becauſe, the neceſſary mutual *Attraction*, between the Earth, and a main Cloud *powerfully electrified*, muſt I think, invariably [or almoſt invariably] cauſe the *lower Parts of ſuch main Cloud*, to extend themſelves *ſtrongly downwards* towards the Earth: forming, as it were, a ſet of *ſmall ſecondary Clouds*, at the *lower ſide*, of the main Cloud.

§ 454. There is the more reaſon to think, that *this* muſt be the caſe, from the above-mentioned important Propoſition; *viz.* that, the *Denſity of the Electricity, of electrical Atmoſpheres, is in the inverſe Ratio of the*

Square of the Diſtance. Whence, it does neceſſarily follow, that, the *lower Parts* of an electrified Cloud muſt (on account of their greater Proximity to the Earth,) be *much more powerfully attracted* towards the Earth, than *any other Parts* of ſuch electrified Cloud.

§ 455. But, from another weighty conſideration above mentioned, there is ſtill greater reaſon to think; that, before a *charged main Cloud* can come within a *ſtriking Diſtance* of the Earth, it muſt invariably [or almoſt invariably] happen, that, ſome of the above-mentioned kind of ſmall *ragged, pending* Clouds will be formed to the *under ſide* of ſuch electrified main Cloud.

For, we have ſeen, † that every *conducting* Body, immerged in the *electrical Atmoſphere* of any charged Body (as of a Thunder-Cloud), will, at its End, or Side, which is the *neareſt* to ſuch charged Body, become charged, with an Electricity *contrary* to *that* of the charged Body itſelf, that produces ſuch electrical Atmoſphere *ſuperinduced.* And therefore, †† that all the *conducting Subſtances*, upon the Surface of the Earth, will become *poſitive*, if the electrified Cloud [immediately over head] be *negative*; or will become *negative*, if the Cloud be *poſitively* electrified.

§ 456. Now, if that Portion of the Earth, which is immediately underneath a *negative* Cloud, be thus rendered *poſitive*; it is an evident conſequence, of the clear Principles above laid down, [that, by ſuch *Portion* of the

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† § 72 and § 358. †† See § 359, and the beginning of § 361.

Earth being *poſitive*, and the *electrical Atmoſphere* of ſuch Portion being, of courſe, alſo *poſitive*,] the *lower Parts* of ſuch a *negative* Cloud, muſt, of *all* the Parts of the Cloud, become the moſt *negative*. Alſo, if that Portion of the Earth, which is immediately underneath a *poſitive* Cloud, be rendered *negative*; it, in like manner, evidently follows, that [by ſuch *Portion* of the Earth being *negative*, and the *electrical Atmoſphere* of ſuch Portion being, of courſe, alſo *negative*,] the *lower Parts* of ſuch a *poſitive* Cloud, muſt, of *all* the Parts of the Cloud, become the moſt *poſitive*.

§ 457. Therefore, whether a *main Cloud*, be electrified *in plus* or *in minus*; it will be invariably true, that, *the lower Parts*, *of ſuch main Cloud* (independently of their above-† mentioned greater *Proximity* to the Earth) muſt, on account of their *higher Degree of electrical Charge*, neceſſarily be *more violently attracted*, than *any other Part* of the electrified Cloud, by that Portion of the Earth, which is immediately underneath, and which is, thereby, in an electrical ſtate *oppoſite* to that of the Cloud: Except in thoſe Caſes, when there are, upon the Surface of the Earth, any kind of *high* and *pointed Conductors*, either *artificial* (like thoſe of Dr. *Franklin*), or elſe *natural* (ſuch as lofty Trees, with very *prominent* Tops, bearing *ſharp* green Leaves, &c.) which Conductors are able to cauſe ſo ſtrong an *electrical ſilent Diſcharge* to take place, from the electrical Atmoſphere *ſuperinduced*, as to *unelectrify thoſe ſmall pending Parts* of the ragged main Cloud; and, thereby, to cauſe them to be *attracted* up again [in

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† See § 454.

the manner explained above § 451] to the electrified *main Cloud* to which they did originally belong.

§ 458. There are alſo Experiments of mine, which I think tend, in a convincing manner, to prove the *infinite* ſuperiority, of *prominent acute metallick Points* [properly connected with the Common-Stock], above conducting Rods terminated in *Balls* or *rounded Ends*; with reſpect Clouds to *ragged* or *ſecundary* ~~Clouds~~ *pending* to the under ſide of an electrified main Cloud.

Theſe Experiments, which are as follows, will ſhew;

1*ſt*. That, ſuch *prominent Points* will tend to *prevent* a main Cloud, whoſe electrical Atmoſphere is *ſuperinduced* upon the Earth, from extending any *ſecundary* Clouds, from its under Side, towards the Earth.

2*dly*. That, ſhould ſuch *ſecundary* or ſmall *pending* Clouds be already formed, at the under Side, of a charged main Cloud; ſuch *prominent metallick Points* will cauſe them to be *attracted* up again, to the Body of the main Cloud.

And 3*dly*. That, *metal Balls* or *rounded Ends* will, in *both* theſe Caſes, tend to produce an *oppoſite* Effect.

EXPERIMENT 44.

§ 459. I took a ſmall Beam, of hard wood, (about five Fig. 19. feet long) perfectly free from Points, or ſharp Edges, and of the form repreſented by ABD in the Figure. The Part AB was about fifteen inches long. I placed this ſmall Beam upon a wooden ſtand EF (about five feet high) that was terminated in a metallick Point G: the ſmall Beam reſted, in the middle, upon this Point G; upon which, it was able to turn, as upon a Pivot.

§ 460.

§ 460. At the End AB, of the Beam ABD, I ſuſpended, by two inſulating ſilken threads AH and BI, an hollow Cylinder of Tin KL, rounded at each end (about three feet four inches long, by nearly four inches and an half diameter), and weighing upwards of two pounds and an half. A Counterpoiſe M was ſuſpended to the other End D, of the ſmall Beam ABD.

§ 461. I then placed a large Tin Prime-Conductor PC (about nine feet eight inches long, and of above ten inches diameter) *in contact* with the End L, of the ſuſpended Tin Cylinder KL.

§ 462. At the Diſtance of about fifteen inches, from the other End K, of the ſuſpended Tin Cylinder KL; I placed a *round poliſhed Braſs Ball* (as repreſented by the *dotted* Lines at N, in Figure 19), properly connected with the Common-Stock. This *Ball* was about *three inches* diameter.

§ 463. Upon my charging the large Prime-Conductor PC; the ſuſpended Tin Cylinder KL began to be *repelled*, from that Prime-Conductor. Now, as ſoon as the End K, of the ſuſpended Tin Cylinder KL began to come near to the *round Braſs Ball* N, (as repreſented in Figure 20); that End K of the Tin Cylinder, did rather incline downwards towards that *round metallick Ball*, and did diſcharge thereon, with an *Exploſion*, the Electricity, which it had received from the electrified Prime Conductor.

EXPERIMENT 45.

§ 464. Having totally diſcharged, not only the Tin Cylinder KL, but alſo the Prime-Conductor PC; I brought that Tin Cylinder again *into contact* with the Prime-Conductor, in the manner mentioned above, in § 461.

§ 465. I removed the *Braſs Ball*, (ſee the *dotted* Lines at N, in Figure 19); and I placed, inſtead thereof, at the *ſame* Diſtance [of fifteen † inches] from the Tin Cylinder KL, a *ſharp metallick Point* N. Fig. 19.

§ 466. I then charged the Prime-Conductor, as I had done before. Now, the ſuſpended Tin Cylinder; inſtead of being *repelled*, as in the former Caſe, from the Prime Conductor PC, towards the *metal Ball*; was only repelled, from the Prime-Conductor, to the Diſtance of about *half an Inch*, or leſs: upon which, the Tin Cylinder KL became *unelectrified*, or nearly unelectrified, by the gradual operation of *ſilent Diſcharge*, through the *acute metallick Point* N. The Tin Cylinder KL was then *attracted* to the Prime-Conductor. The Tin Cylinder, becoming again charged, was again repelled, from the Prime-Conductor, to the ſame *ſmall Diſtance* (of about half an inch, or leſs,) when it was again *attracted* by the Prime-Conductor.

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† See § 462.

And, as long as the *Point* N remained in the Poſition, repreſented in the Figure; the ſuſpended Tin Cylinder Fig. 19. KL *never removed* to a *greater Diſtance* from the Prime Conductor.

EXPERIMENT 46.

§ 467. I then very *gradually* approached the *metallick Point* N, towards the End K, of the ſuſpended Tin Cylinder KL; till it came almoſt *in contact* with it.

The *nearer* I approached the *Point*, the *ſmaller the Diſtance* became, to which, the ſuſpended Tin Cylinder KL was repelled, from the Prime-Conductor PC; till at laſt, *that Diſtance* became ſo *ſmall*, as ſcarce to be at all perceptible.

Another Set of Experiments of mine is, as follows.

EXPERIMENT 47.

§ 468. I faſten a very *fine* [*gold*, or] *ſilver*, † *ſilken Thread* AB, to the under Side of a Prime-Conductor PC, by means of a ſmall piece of beeſwax, or other *non-conducting* ſubſtance, of about one quarter of an inch, or more, in length. I then ſcrape off, from the upper End of this Thread, the Silver, ſo as to lay the *Silk* perfectly bare all round, for the ſpace of about *one twelfth* of an inch: taking care, that the Metal, on each ſide of this interruption, ſhould not ſtick out in Points, but lay quite contiguous to the Silk.

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† This Thread (in order for theſe Experiments to ſucceed in the beſt manner poſſible) ſhould be one of the *very fineſt* of the ſort, that are uſed in making [gold, or] ſilver Lace.

I repeat this, the whole length of the Thread, at equal intervals, of about ~~half~~ one eigth of *an inch* in length; in which ſpaces (of ~~half~~ an eigth of an inch), the ſilver, therefore, remains un-touched.

§ 469. In order, to perform the following Experiments fairly; it is neceſſary to obſerve, that, at the above-mentioned interruptions (of about *one twelfth* of an inch); the Silk be well bent to and fro', to render it quite pliable in thoſe places; ſo as to enable it to move, in all poſſible ways, with perfect *freedom.*

§ 470. As to the *length* of the Thread; it muſt depend, principally upon the ſtrength of the electrical Apparatus; but, likewiſe upon the weight of the Thread itſelf, and upon the number, and the ſize, of the interruptions in the ſilver.

When I uſe my largeſt Prime-Conductor; I generally make the Thread from *fifteen* to *twenty* inches long: but, I make it, only of *four* or *five* inches in length, when I apply it to a very ſmall Prime-Conductor.

§ 471. It is much better to make the Thread too ſhort, than too long: becauſe, if it be too long, the following Experiments cannot, in the nature of things, ſucceed properly; but, if it be ſhorter than is neceſſary, they will nevertheleſs, ſucceed conſtantly.

§ 472. I now cauſe the Glaſs Cylinder to be turned, in order to charge the Prime-Conductor PC, to which, the above-mentioned fine *ſilver ſilken Thread* AB is Fig. 21. faſtened.

Towards the lower Extremity of the Thread AB, which now becomes electrified, I approach any metallick Body DE, that is free from Points, that is connected† with the Earth, and whoſe Extremity D is terminated in a *Ball* or *rounded End*; upon doing which, that Thread is *attracted* by the *round* metal Body DE; as repreſented in the Fig. 21. Figure. When the *round* metal Body DE, is brought near the End B of the Thread; the electrical *Charge* of the Prime-Conductor PC is conducted, with a *ſudden Exploſion*, upon the *round* Body DE, through the ſilver ſilken Thread AB; appearing, with a bright Light, in all the interruptions of the Metal. The Thread moreover flies about, from time to time, with great violence, as long as the *round* Body DE is kept near it; repeatedly conveying down, with an *Exploſion*, upon that *round* Body, the electrical Charge of the Prime-Conductor; as faſt as the Glaſs Cylinder is able to renew ſuch Charge.

EXPERIMENT 48.

§ 473. I now approach again, the ſame *round* Body Fig. 22. DE, towards the ſame *electrified ſilver ſilken Thread* AB; (*not* towards the lower End B, of that Thread, as in the laſt Experiment, repreſented in Figure 21; but,) in the manner repreſented in Figure 22. The Conſequence of which is, that, as ſoon as the Prime-Conductor becomes fully charged; the lower End B, of the electrified Thread, Fig. 22. is *attracted* by the *round* metal Body DE; as is ſeen in the Figure.

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† I generally cauſe the metal Body DE to communicate with the Earth, by means of a Wire LM.

The *Charge* of the Prime-Conductor is again ſuddenly conducted, upon the *round* Body DE, with an *Exploſion*; and the electrified Thread AB again flies about, from time to time, with violence; as in the former Experiment. And, as long as the Body DE remains in the ſame ſituation, the *ſame Effects* repeatedly take place, and produce a beautiful appearance.

§ 474. In repeating theſe Experiments, with the *round* metal Body DE; it is proper, to ſupport that *round* Body, upon a ſtand; or to hold it up, by means of an *inſulating* handle, as repreſented by FG, in the Figures 21 and 22: becauſe, if the Prime-Conductor be large, and powerfully charged; the electrical Strokes, conducted upon the *round* Body, through the ſilver ſilken Thread, would otherwiſe be felt ſeverely.

EXPERIMENT 49.

§ 475. In this Experiment, I fix a *ſharp metal Point* Fig. 23. H (of two or three inches in length), into the End D, of the metallick Body DE.

The Prime-Conductor PC being fully charged; I approach this *Point* H, towards the *electrified ſilver ſilken Thread* AB: upon doing which, that Thread ſhrinks from the *metallick Point*; and [in the manner repreſented in Figure 23,] flies up to the Prime-Conductor, being *attracted* by it.

§ 476. I think, that; independently of the reſpectable Teſtimony of Mr. *Wilcke*, as mentioned above (§ 452); there cannot be a doubt, but, that *Effects*, in ſubſtance *ſimilar* to thoſe exhibited in theſe Experiments, muſt often, of neceſſity, take place in *natural Electricity*.

PART XVII.

SECTION 477.

HAVING examined what Effects would be produced, if there be any ſmall Clouds *pending* to the under Side, of a main Cloud; let us now conſider what muſt happen, if there be any ſmall Clouds *floating* [totally *independent* of the main Cloud,] between the main Cloud and the Earth.

§ 478. Now, it is evident, that ſuch *floating* Clouds can *only* be, in one of the *three* following States; namely,

1*ſt*. Either, electrified with the *contrary* Electricity to the main Cloud;

2*ndly*. Electrified with the *ſame* Electricity as the main Cloud;

Or 3*rdly*. *Not* electrified *at all*.

§ 479. Firſt, let us ſuppoſe that the *floating* Cloud, be electrified with the *contrary* Electricity, to that of the main Cloud.

It is moſt evident, from the very nature of a *ſtriking Diſtance*, as explained above †; that, in order, for ſuch *floating*

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† § 28 and § 29.

floating Cloud to be able to *tranſmit*, to the Earth, any *main Stroke of Exploſion* from an electrified main Cloud; it is indiſpenſably neceſſary, that the *Denſity of the Electricity*, of *that Part* of the main Cloud's electrical Atmoſphere, which is *between* ſuch main Cloud and the *floating* Cloud above mentioned, muſt be *very conſiderable*. For, elſe, it would *not be capable of conducting the electrical Charge* of the main Cloud, even *as far* as the *floating* Cloud. Therefore, much leſs would it be capable of conducting ſuch Charge, with *a ſufficient Power of electrical Atmoſphere*, to be again *tranſmitted* from ſuch [*oppoſitely* electrified] *floating* Cloud, to Bodies on the Surface of the Earth.

§ 480. Now, it is evident; that, long *before* the *floating* Cloud and the main Cloud, can come *near enough* to each other, for a *Stroke of Lightning* to paſs from the one to the other; their [*oppoſitely* electrified] Atmoſpheres muſt, of neceſſity, *interfere* ſo ſtrongly, that ſuch *floating* Cloud will no longer remain *floating* [*independent* of the main Cloud] between the main Cloud and the Earth, but will be *attracted up* to the Body of the *main Cloud:* ſince, it is a general Rule (as was explained above, § 23), that, *moveable Bodies, which are charged with contrary Electricities, muſt attract each other, whenever their* [*oppoſitely electrified*] *Atmoſpheres interfere.*

§ 481. But, if the above-mentioned *floating Cloud* be thus *attracted up* to the Body of the *main Cloud*; ſo far, will ſuch *floating* Cloud be, from ſerving to *tranſmit* any *main Stroke of Exploſion* from ſuch main Cloud to the

Earth; that, it will tend to *deſtroy a Part of the Charge* of the main Cloud: ſince, (by our Hypotheſis,†) the above-mentioned *floating Cloud* was charged with the *contrary* Electricity, to that of the *main Cloud.*

§ 482. That is to ſay, that the ſmall *floating* Cloud; inſtead of contributing, in *this* Caſe, to make the *main Cloud* ſtrike to a *greater* Diſtance, than it would otherwiſe have done; will, on the contrary, (in proportion to the Quantity of its *oppoſitely* electrical Charge) tend to *unelectrify the main Cloud*; and will conſequently, tend, in a proportional Degree, [not to *increaſe*, but] to *diminiſh its ſtriking Diſtance.*

§ 483. Let us ſuppoſe, in the next place, that the ſmall Cloud, *floating* between the main Cloud and the Earth, be charged with the *ſame* kind of Electricity, as that of the main Cloud.

In this Caſe, it muſt happen, from the Laws of Electricity explained above††; that, the *ſmall floating Cloud* will be *repelled* by the electrified main Cloud.

§ 484. Now, if ſuch ſmall *floating Cloud*, when it deſcends, ſhould find, upon the Surface of the Earth, no other conducting Bodies, but ſuch as are terminated in *Balls* or *rounded Ends*; it is evident, from what has been ſaid above, that, the ſmall *floating Cloud* will be *attracted* towards them, and will diſcharge, with an Exploſion, its

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† See § 479.

†† See § 24, § 25, § 26 and § 27.

Electricity, thereon. And, ſuch ſmall *floating Cloud*, may alſo, under certain circumſtances, be able to *tranſmit*, with an *Exploſion*, upon ſuch *metal Balls*, or *rounded Ends*, the *whole Charge* of the electrified *main Cloud* itſelf.

§ 485. Whereas, were there to be, upon the Surface of the Earth in ſuch Place, conducting Bodies, terminated (not in *Balls* or *rounded Ends*, but) in very *prominent and acute metallick Points*, properly connected with the Com-mon-Stock; then, ſuch ſmall *floating Cloud*, muſt (by the Electricity of its electrical Atmoſphere being ſilently diſcharged through ſuch *prominent and ſharp metallick Points)* be gradually rendered *unelectrified*, or nearly *unelectrified*. Becauſe; ſince, the gradual operation of *ſilent Diſcharge* through metallick *Points*, is capable of *unelectrifying* Clouds that are even near the Body of a *main Cloud*, as was above explained † and related ††; it is evident, that ſuch operation of *ſilent Diſcharge* muſt, *a fortiori*, be able to cauſe a ſmall *floating Cloud*, which is ſtill nearer to the Earth, to become *unelectrified*, or nearly unelectrified. The neceſſary conſequence of which muſt be, that ſuch ſmall *floating Cloud* would be *attracted* up to the Body of the *main Cloud*, in a manner ſimilar to that explained above in PART XVI, or ſimilar to that hereafter ††† to be explained; by which means, *no main Stroke of Exploſion* could poſſibly be tranſmitted, through ſuch ſmall *floating Cloud*, upon any Building that is ſecured

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† § 451, § 457, § 466, § 467 and § 475. †† § 452.

††† From § 486, to § 492 incluſively.

-cured by proper conducting Rods, terminated in ſuch *prominent and very acute metallick Points.*

§ 486. Laſtly, let us ſuppoſe †, that, the ſmall *Cloud, floating* between the main Cloud and the Earth, be *not electrified at all.*

It is evident, when ſuch ſmall *floating Cloud* comes to be within the ſenſible Part of the *electrical Atmoſphere* of the main Cloud; that, it will (in a Manner ſimilar to that above †† explained,) have its *upper* Side, [which is the *neareſt* to the main Cloud,] become electrified with the *contrary* Electricity to that of the main Cloud.

§ 487. The neceſſary conſequence of which muſt be; that, thoſe *upper Parts* of the ſmall *floating* Cloud, which thus become electrified with the *contrary Electricity* to that of the main Cloud, will be *attracted* up to the Body of the main Cloud.

§ 488. Whence, one of *two Things* muſt neceſſarily happen; *viz.*

Either, that the *lower Parts*, of the ſmall *floating* Cloud [which, from what was ſaid above †††, muſt, of neceſſity, have become electrified with the *ſame* Electricity as that of the main Cloud,] will be *attracted* up, together with the *upper Parts* of ſuch floating Cloud, to the Body of the main Cloud:

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† See § 478. †† § 72. ††† See § 72.

Or, that thoſe *lower Parts*, of ſuch ſmall *floating* Cloud, will *not* be *attracted* up to the Body of the main Cloud; but, will, as the *upper Parts* riſe up, extend themſelves [either *abſolutely*, or *relatively*] downwards towards the Earth.

§ 489. Now, let us ſuppoſe; according to the *firſt* of theſe Caſes; that, *every Part*, of the ſmall *floating* Cloud, be *attracted* up to the Body of the *main Cloud.*

Then, it is evident, that, ſuch ſmall *floating* Cloud, under theſe circumſtances, *cannot poſſibly tranſmit,* any *main Stroke of Exploſion,* to any Bodies on the Surface of the Earth.

§ 490. Next; let us ſuppoſe; according to the *ſecond* of theſe Caſes; that [when the *upper Parts,* of the ſmall *floating* Cloud, riſe up to the Body of the main Cloud;] the *lower Parts*, of ſuch ſmall *floating* Cloud, do extend themſelves, either *abſolutely* or *relatively*, downwards towards the Earth.

Then, it is evident (from what has been ſaid† above), ſhould there be, upon the Surface of the Earth underneath, no other conducting Bodies, but ſuch as are terminated in *Balls* or *rounded Ends*; that, ſuch *lower Parts*, of the ſmall *floating* Cloud, as have [agreeably to our *preſent* Hypotheſis] a tendency downwards, muſt be attracted towards ſuch *Balls* or *rounded Ends.* By means of which, a *direct main Stroke of Exploſion* will take place, from ſuch *lower Parts* of the floating Cloud. And, under certain circumſtances, even the *whole Charge* of the *main Cloud*

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† § 484.

Cloud itſelf, may be *tranſmitted*, with an *Exploſion*, by the *floating* Cloud, upon ſuch *Balls* or *rounded Ends*.

§ 491. It is no leſs evident; if there were to be, on the Surface of the Earth, conducting Bodies terminated in *prominent and acute metallick Points*, properly connected with the Common-Stock; that, ſince, ſuch *metallick Points* are able (as was above explained † and related ††,) to cauſe the *depending Parts*, even of a *main Cloud*, to become *unelectrified*, or nearly unelectrified; *a fortiori*, will ſuch *prominent metallick Points* be able to produce the *like Effect*, upon the *depending Parts* of a *ſecundary*, or ſmall *floating* Cloud.

The neceſſary conſequence of this will be, that, ſuch *lower* or *depending Parts*, of the ſmall *floating* Cloud, will be *attracted* up to the Body of the *main Cloud*.

§ 492. But, we have ſeen above (§ 487 and § 490), that, the *upper Parts* of ſuch *floating* Cloud, have *already* been *attracted* up to the Body of the *main Cloud*.

Therefore, it is evident; ſince, all the *Parts* of the *floating* Cloud, are thus *attracted* up to the Body of the main Cloud; that, ſuch *floating* Cloud will *not* be able, to ſerve as *the Means* of *tranſmitting any main Stroke of Exploſion*, from the main Cloud, to Bodies upon the Surface of the Earth.

§ 493. *All* the Propoſitions here ſtated, are immediate and evident Conſequences, of the clear and unalterable *Principles*

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† § 451, § 457, § 466, § 467 and § 475.

†† § 452.

Principles of Electricity, which I have laid down above. And the Reader will, I truſt, by this time, be thoroughly convinced, that *metallick Conductors*, properly connected with the Common-Stock, and terminating in very *prominent and ſharp metallick Points*, have a powerful and moſt admirable tendency, to prevent any *main Stroke of Lightning* [whether *direct* or *tranſmitted*] from taking place, upon ſuch *high and acutely pointed Conductors*.

P A R T XVIII.

SECTION 494.

HAVING ſhewn, in what Manner, and from what Principles, Conductors, terminated in *prominent acute metallick Points*, tend to ſecure both Perſons and Buildings, againſt any *main Stroke of Exploſion*; whether ſuch *main Stroke* threatens to come *directly* from the *main Cloud* itſelf; or to be *tranſmitted*, by means of any ſmall ragged Clouds *pending* to the under ſide of the main Cloud, or by means of any ſmall Clouds *floating* [totally *independent* of the main Cloud] between the main Cloud and the Earth: I will now ſay a few Words, relative to the *lateral Exploſion*, and the *returning Stroke*.

§ 495. *Firſt*, with reſpect to the *lateral Exploſion*; which, as I have ſaid above [in SECTION 386], does always proceed *immediately* from the *main Stroke*, and is occaſioned *ſolely* by it: it is evident, that, when there is *no main Stroke*, there *cannot* be any *lateral Exploſion* whatſoever.

§ 496. Therefore, having proved, that *high and acutely pointed Conductors* tend powerfully to prevent any *main Stroke of Exploſion* from taking place; I have, in fact, at the ſame time, demonſtrated, that *high and pointed Conductors* tend powerfully to prevent alſo the *lateral Exploſion.*

§ 497. Now, with reſpect to the *returning Stroke*; it is evident [from its very nature as explained above,†] that, it *cannot exiſt*, in any *given* Place, without ſome *main Stroke of Exploſion* burſting *on a ſudden*, from *ſome* Part of the Thunder-Cloud (or other charged Body), whoſe electrical Atmoſphere is *ſuperinduced* upon that *given* Place.

§ 498. I have alſo fully ſhewn, in the foregoing Pages††, that *high and pointed* Conductors, (properly) erected in any *given* Place, will tend moſt ſtrongly to prevent any *main Stroke of Exploſion* [whether *direct*, or *tranſmitted*] from happening, in ſuch *given* Place.

§ 499. Therefore, it is evident, that ſuch *high and pointed Conductors* will, of neceſſity, tend moſt ſtrongly to prevent likewiſe *any returning Stroke* from happening, in ſuch *given* Place, where ſuch Conductors are erected.

§ 500. But, as it is extremely poſſible (as I have fully demonſtrated†††), that, *Perſons* and *Animals* may be deſtroyed, and that *particular Parts of Buildings* may be

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† See § 208, § 311, § 346 and § 387.

†† From PART XIII, to PART XVII incluſively.

††† PART XI.

be conſiderably damaged by a *returning Stroke*, which may be produced by an electrical *main Exploſion* taking place, even at a *very conſiderable Diſtance* from ſuch Perſons, Animals, or Buildings: I ſhall now ſhew, that; whatever might be [from any *given* Place] the *Diſtance*, at which, ſuch electrical *main Exploſion* might happen; *all the deſtructive Effects*, to be apprehended from a *returning Stroke*, would, by means of *elevated and acutely pointed Conductors*, (properly) erected in ſuch *given* Place, be entirely prevented.

I have verified *this*, by the following clear and unambiguous Experiments.

EXPERIMENT 50.

§ 501. The whole Apparatus being arranged, preciſely in the *ſame* Manner, as it was in my EXPERIMENTS 38 and 39, mentioned above (from § 280, to § 293); the *Diſtance*, between the *neareſt* of the two inſulated Bodies Fig. 15. IQ and OT, and the Prime-Conductor PC, being *four feet*; each of the Perſons, ADB, and FHG, felt the *returning Stroke*, in both their Hands, at the inſtant that the Prime-Conductor PC did *ſuddenly* diſcharge, with an Exploſion, its Electricity, upon the large metal Ball L; ſee Figure 15.

EXPERIMENT 51.

Fig. 15. § 502. But, having placed, at the *ſame* Diſtance, of *four feet*, from the Prime-Conductor PC, a very *prominent*,

-*nent*, *tapering and acute ſteel Point* S, which communicated with the Earth, by means of a metal Stand NN, and a Ribband of Lead YY: the Prime-Conductor PC *ceaſed ſtriking* upon the metal Ball L, which was at the Diſtance of about *ſeventeen inches* from the Ball C of that Prime-Conductor. The Conſequence of which was, that, *no returning Stroke* took place, between the Men, ADB, and FHG.

EXPERIMENT 52.

§ 503. Leaving the Prime-Conductor PC, the Bodies IQ and OT, the Men ADB and FHG, &c. and alſo the metal *Point* S, in exactly the *ſame* ſituation, as in the laſt Experiment: I approached the large metal Ball L, about *four* inches *nearer* to the Ball C, of the Prime-Conductor PC, than in the laſt Experiment; in order to draw forth an *Exploſion* upon that metal Ball L, notwithſtanding the metal *Point* S, that was placed at the Diſtance of *four feet* from the Prime-Conductor. Fig. 15.

Now, when the *Exploſion* took place upon the Ball L; *neither* the Man ADB, *nor* the Man FHG, felt any *returning Stroke*.

§ 504. The Reaſon of this evidently was; that, the *prominent acute Point* placed at S, was able *gradually* to *carry off* the *Electricity*, contained in the Skirts of the ſenſible Part, of the Prime-Conductor's *ſuperinduced* electrical Atmoſphere; as faſt as ſuch *Electricity*, contained in the Skirts of ſuch *ſuperinduced* electrical Atmoſphere, was able gradually to flow towards the *Point* S, or (which was in fact, the ſame thing) towards the *Bodies* IQ and OT, the *neareſt* of which Bodies was, at the *ſame Diſtance* [as the metal *Point* itſelf was] from the Prime-Conductor.

§ 505. Now, from what we have ſeen above †, concerning the Nature of an electrical *returning Stroke*; it is evident, that, in order, for any *returning Stroke* to take place, it is abſolutely neceſſary; that, the *conducting* Body, or Bodies, which would be to *occaſion* the *returning Stroke*, ſhould [previouſly to the *main Exploſion*,] be expoſed to a certain Degree of *ſuperinduced* elaſtick *Preſſure*, from the Electricity, contained in the *electrical Atmoſphere*, of the Thunder-Cloud which produces the *main Exploſion*.

§ 506. But, I have ſhewn above (§ 369), that, a *prominent and acute metallick Point*, properly connected with the Earth, will be able *gradually to diſcharge* any *Electricity*, that might be conveyed to its upper Extremity, by the *ſuperinduced electrical Atmoſphere*, of a Thunder-Cloud, or of any other charged Body whatever.

§ 507. Therefore,

Since, the *prominent acute metallick Point* S, did, [in Fig. 15. my EXPERIMENT 52, mentioned above in § 503] *gradually carry off the Electricity* contained in the Prime

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† § 208, § 311, § 346 and § 387.

Conductor's electrical Atmoſphere *ſuperinduced*; which *Electricity* was the *only Cauſe*, that could produce, *an electrical returning Stroke*, in the Caſe before us: it is evident, that, the *metal Point* S, muſt, by *removing* that *given Cauſe*, neceſſarily *prevent an Effect* which could only be produced by the immediate operation of ſuch *given Cauſe*. That is to ſay, that, the *metal Point* S, muſt, of neceſſity, *prevent*, in the Caſe before us, *the electrical returning Stroke*.

EXPERIMENT 53.

§ 508. Every thing being arranged *preciſely* in the *ſame manner*, as in the *laſt* Experiment (ſee § 503); I took an hollow, poliſhed *Ball* of Braſs, of about *three inches* diameter, and I put this *Ball* upon the metal *Point* S; as repreſented by the *dotted* Lines at S, in the Figure. Fig. 15.
The Effect, produced by this ſingle circumſtance, of covering the *acute Point* S with this *round metal Ball*, was; that, *each time*, that an Exploſion took place, from the Prime-Conductor PC, upon the other metal Ball L; both the Men, ADB and FHG, received an electrical *returning Stroke*.

§ 509. The Reaſon of which Effect evidently was, that, the *metal Ball* at S was *not* able [as the *acute Point* had been] gradually to *diſcharge*, into the Earth, *the Electricity*, contained in the Prime-Conductor's *ſuperinduced* electrical Atmoſphere.

This tends ſtrongly to confirm the *Theory*, which I have laid down in the foregoing Pages of this Treatiſe.

EXPERIMENT 54.

§ 510. I then decreaſed the *Diſtance*, between the Fig. 15. Bodies IQ, OT, and the Prime-Conductor PC, from *four feet* to *three feet and an half*, then to *three feet*, then to *two feet and an half*, then to *two feet*, then to *twenty inches*, and laſtly to *eighteen inches*. The *Diſtance* between the Ball C of the Prime-Conductor, and the large Ball L, being (as in the two *laſt* Experiments) *thirteen inches*. And *each time*, that I thus approached the Bodies IQ and OT, gradually nearer to the Prime Conductor; I placed the *Ball* S, at a variety of *different Diſtances* from that Prime Conductor.

The electrical *returning Stroke* invariably took place with its uſual force. And there was *no one Diſtance* from the Prime-Conductor [beyond the *ſtriking Diſtance*, which was about *thirteen inches*], at which, if the *Ball* S was placed, that *Ball* did either *prevent*, or *weaken* in any Degree, the electrical *returning Stroke.*

EXPERIMENT 55.

§ 511. And when the *Diſtance*, between the Bodies IQ, OT, and the Prime-Conductor PC, was from *ſixteen* to *fourteen* inches; the two Men, A B and FHG, felt a violent *returning Stroke*, ſimilar to the ſudden Diſ-

-charge of a *Leyden Jar*; the *metal Point* at S ſtill remaining covered by the Braſs Ball above-mentioned.

EXPERIMENT 56.

§ 512. The *returning Stroke* equally took place, when the *Ball* S was moved ſufficiently near to the Prime-Conductor, to be itſelf within the *ſtriking Diſtance*; as was evident, from the *Theory*, would be the Caſe.

EXPERIMENT 57.

§ 513. But, if the Ball S was placed *much within* the *ſtriking Diſtance* of the Prime-Conductor; then, the *ſtrength* of the *returning Stroke*, was decreaſed.

The Reaſon of which evidently was, that, the *metal Ball* S, in ſuch caſe, prevented the Prime-Conductor PC from ever acquiring its *full Charge*; inaſmuch as it conſtantly drew forth an Exploſion from it, before it became duely electrified.

EXPERIMENT 58.

§ 514. Having removed the Braſs Ball, from the metal *Point* at S; I placed the Bodies IQ and OT, at the Diſtance of *fourteen inches* from the Prime-Conductor PC; the Diſtance, between the Ball C of the Prime-Conductor, and the large metal Ball L, being (as before) *thirteen inches*.

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I placed the *acute Point* S, in *this* Experiment, always further from the Prime-Conductor, than at the above mentioned Diſtance of *fourteen Inches.*

The *Point* S, when placed within the Diſtance of about *three feet* from the Prime-Conductor; always prevented that Prime-Conductor from *exploding* † upon the large metal Ball L; and conſequently, prevented alſo any *returning Stroke* from taking place.

EXPERIMENT 59.

§ 515. I then removed the *acute Point* S, *ſix inches further* from the Prime-Conductor; in order, *not* to prevent it from *exploding* upon the Ball L.

The *Point* S (tho' it was in this caſe, *three* times further from the Prime-Conductor, than the *neareſt* of the Bodies IQ and OT,) did notwithſtanding, *weaken* very conſiderably the *returning Stroke*; inaſmuch at *that acute Point*, even at that Diſtance, cauſed the Prime-Conductor's *electrical Atmoſphere* to become (in the Manner explained above, in § 397,) *more rarefied throughout.*

EXPE-

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† A *prominent acute metal Point*, placed at a *greater* [and ſometimes even at a *much greater*] *Diſtance* from a charged Prime-Conductor, than a large *metal Ball* is, will often prevent ſuch *Ball* from being *ſtruck*; tho' ſuch *Ball* would otherwiſe have been *within the ſtriking Diſtance* of the electrified Prime-Conductor. I believe, that the late Mr. *Henly*, F. R. S. was the firſt who obſerved this intereſting Fact, which is moſt eaſily accounted for, from my Principles of Electricity laid down above; inaſmuch, as a *prominent acute metallick Point*, immerged in any *electrical Atmoſphere*, tends (in the Manner explained in PART XIV) to render ſuch electrical Atmoſphere *more rarefied throughout.*

EXPERIMENT 60.

§ 516. The Diſtance, between the Ball C of the Prime-Conductor, and the large metal Ball L, being (as in the laſt-mentioned Experiments) *thirteen inches*: I placed the two Bodies IQ and OT, at *all* the following Diſtances; namely, at *ſix feet*, at *five feet and an half*, at *five feet*, at *four feet and an half*, at *four feet*, at *three feet and an half*, at *three feet*, at *two feet eight inches*, at *two feet four inches*, at *two feet*, at *twenty inches*, at *eighteen inches*, at *ſixteen inches*, at *fifteen inches*, and laſtly at *fourteen inches*. I always placed, *each* time, the *acute metal Point* S, at the *ſame Diſtance* from the Prime-Conductor, as the *neareſt* of the two Bodies, IQ and OT, was, from that Prime-Conductor. Fig. 15.

Neither of the Men, ADB or FHG, felt *any returning Stroke*, in any of theſe Caſes: ſuch was the admirable Effect, produced by the *prominent acute Point* at S.

EXPERIMENT 61.

§ 517. It is almoſt unneceſſary to relate; that, when in *each* of the Caſes here-mentioned, I placed the *acute Point* S, at any Diſtance from the Prime-Conductor, that was *leſs than the Diſtance*, between that Prime Conductor, and the *neareſt* of the Bodies IQ and OT; there was *not* any *returning Stroke*. Becauſe, it is evident, *a fortiori*, that, in ſuch Caſe, *no* electrical *returning Stroke* could take place.

§ 518. Conſequently, *high and pointed metallick Conductors* [when properly conſtructed, and when made to communicate compleatly with the *Common-Stock*,] tend not only moſt ſtrongly to prevent a *main Stroke of Lightning*, and the *lateral Exploſion*; but tend likewiſe, moſt powerfully to prevent any dangerous *electrical returning Stroke* whatever, from taking place, near that Part of the Edifice, upon which they are erected. So admirable, and ſo extenſive, is the *Principle*, upon which is founded, this ſimple and moſt incomparable Invention; which does not tend merely to *decreaſe the Danger*, ariſing from the various pernicious *Effects* that might reſult from *natural Electricity*; but, which tends even to *remove* (in almoſt *every* Inſtance,) *the immediate Cauſe* of ſuch Effects!

PART XIX.

PART XIX.

SECTION 519.

FOR the ſake of thoſe, who care but little about the detail of the *Theory* of Electricity, but who notwithſtanding, may be extremely intereſted in the Knowledge of the beſt Method of *ſecuring Buildings* againſt damage by Lightning; I ſhall here ſtate, in a few Words, the *neceſſary Requiſites* in erecting Conductors; which *Requiſites* will appear to be *eleven* in number.

1*ſt*. That the *Rods* be made of ſuch Subſtances, as are, in their nature, the *beſt Conductors of Electricity*.

2*ndly*. That the Rods be *uninterupted*, and *perfectly continuous*.

3*dly*. That they be of a *ſufficient thickneſs*.

4*thly*. That they be perfectly *connected* with the *Common-Stock*.

5*thly*. That the upper Extremity, of the Rods, be as *acutely pointed* as poſſible.

6*thly*. That it be *very finely tapered*.

7*thly*. That it be extremely *prominent*.

8*thly*. That each Rod be carried, in the *ſhorteſt convenient Direction*, from the *Point* at its upper End, to the *Common-Stock*.

9*thly*. That there be, neither *large* nor *prominent* Bodies of Metal upon the Top of the Building propoſed to be ſecured, but ſuch as are *connected*, *with the Conductor*, by ſome proper metallick Communication.

10*thly*. That there be a ſufficient *Number* of high and pointed Rods.

And 11*thly*. That every Part of the Rods be very *ſubſtantially* erected.

§ 520. *Firſt*, as to the *Subſtance*, of which, a *Conductor for Lightning* ought to be made; I believe there is no Man alive, who has the ſmalleſt idea whatever of Electricity, who can diſſent from the received opinion, that [*cæteris paribus*] a conducting Rod had always beſt be made of that *Subſtance* which is, in its nature, the moſt *perfect Conductor* of Electricity.

Of all the Subſtances we are yet acquainted with; *Metals* are the *beſt Conductors* of Electricity. Therefore, the *Rod* ought to be made of *Metal*.

By ſome very intereſting Experiments, made by the learned Dr. *Prieſtly*†, Mr. *Wilcke*, &c. *Metals* may be ranged according to the following order, with reſpect to their *conducting* Powers; beginning with the moſt perfect, *viz*.

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† See Dr. Prieſtly's Hiſtory of Electricity Page 708
712

Gold,
Silver,
Copper,
Braſs,
Iron,
Tin,
Lead.

§ 521. *Secondly,* the firſt Principles of Electricity teach us, that a metallick *Conductor* ought to be *uninterupted*; and the ingenious Experiments[†] of Mr. *Nairne* F. R. S. ſtrongly confirm us in that opinion.

Nay, it is *not* ſufficient, that the different Pieces of Metal, which compoſe the Rod, ſhould be but merely *in contact*, as the Effect produced by the Lightning upon Mr. *Maine's*[††] Rod (in *South Carolina*), which was made of ſeveral Pieces of Iron only *hooked* together, evidently proves.

A *Conductor* ought, therefore, to be perfectly *continuous*; that is to ſay, it ought to be made of *one continued Piece of Metal*, or of different Pieces connected together [Metal[†††] to Metal] in the *moſt cloſe, perfect and intimate Manner poſſible.* Too much attention cannot be paid to *this* important particular: and without it, the electrical *ſilent Diſcharge* through a *pointed Conductor* muſt be extremely imperfect.

[†] See Mr. *Nairne's* eleventh Experiment, Philoſophical Tranſactions, Volume 68, Part 2, Page 832.
1099

[††] See Dr. Franklin's Philoſophical Works, Page 428
514

[†††] *N. B.* If the different Peices of Metal are joined together by means of nuts and ſcrews, or in any ſimilar manner, *no oil* ought to be uſed; as *oil* is a very *bad Conductor* of Electricity. A very good way, is to put a thin Piece of *ſheet-Lead,* between the ſhoulders of the joints.

§ 522. *Thirdly*, as to the *thickneſs* of a conducting Rod; from all I have ever been able to learn concerning the Effects of Lightning, in any Part of the World, upon metal Bars, Wires, &c; I am thoroughly convinced, if *all* the other *Requiſites* here-mentioned are duely attended to, that, either a *Copper* Rod *half an Inch ſquare*, an *Iron* Rod *one Inch ſquare*, or a *Leaden Rod two Inches ſquare*, [or, which is in effect the ſame thing, the *ſame Quantity of Metal* in any other Form,] would, in any Caſe, be quite ſufficient; tho' the adding of a *greater Quantity of Metal* to the Rod, could (Expenſe excepted) only be advantageous. I muſt however add, that I am well perſuaded, that, in *England*, where Lightning is never ſo violent as in ſome other Countries, *conducting Rods* may, very ſafely, be made with a *ſmaller Quantity of Metal*, than that I have here mentioned; eſpecially, if the Buildings, upon which they are erected, be but *low*.

§ 523. *Fourthly*, conducting Rods ought to be *perfectly connected with the Common-Stock*: for, it is evident, that a *metallick Rod* (however perfect it might be in every other reſpect) cannot poſſibly anſwer the purpoſe thoroughly, either of conducting a *Stroke*, or of conveying Electricity *in ſilence*, to the Common-Stock; unleſs ſuch Rod be *properly connected* therewith.

I apprehend, that one of the greateſt Errors, that have ever been committed in the erecting of Conductors, is, the carrying the lower End of the Rod only a *few feet* into the Earth; particularly, in *thoſe Countries* where the *Earth* is often extremely parched-up and *dry*. Dr. *Franklin* ſays, in a Letter to *Peter Collinſon, Eſq.* F. R. S. that, he had found *ſimple dry Earth*[†] to be an exceeding bad Conductor of Electricity. Neither do I believe, that the adding to *Earth*, any *moderate Quantity of Moiſture*, could make it, by any means, a *ſufficient good Conductor*, to enable it to convey with due *facility*, from the *lower* End of the Rod, any *great Quantity of natural Electricity*, which might either *ſuddenly ſtrike*, or *gradually flow*, to the *upper* End of the Rod: inaſmuch, as it is *not* ſufficient, that the Electricity ſhould be merely able to run out, at the *lower* End of a Conductor; but, that it ſhould be able to run out *with the utmoſt poſſible facility*; as muſt appear evident, from what I have ſaid above, in PART XII.

§ 524. The beſt way, undoubtedly, to anſwer this purpoſe, is, for the lower Extremity of the Rod to be carried into *Water*, at the Diſtance of ten yards or upwards, from the Foundation of the Building upon which the Rod is erected.

§ 525. But, as very frequently, *this* is *not* poſſible to be done, I ſhould recommend, in ſuch Caſes; that a *round*

[†] See Dr. *Franklin's* Philoſophical Works, Page 35 and 36.
514

N. B. Mr. *Delaval* has alſo found that *dry Mould* would *not conduct Electricity*. See Dr. *Prieſtley's* Hiſtory of Electricity, Page 224
712

Rod, made either of *Copper* or of *Lead,* be carried, under ground, from the lower End of the Conductor, to the Diſtance of *fifteen* or *twenty yards* from the Foundation of the Building; and that it ſhould be there properly connected with a *wide* Strip of *Copper* or of *Lead,* ſome *yards* in length, which ought to be made *jagged* at its edges, and which ought to be *ſunk deep* into the moiſt Earth.

§ 526. Now, the Reaſon, for my propoſing, that this Strip of Metal ſhould be *ſunk deep* into the Earth, is; that I conceive, that *Earth,* at a good *depth,* is never *extremely dry.*

The Reaſon for my propoſing, that this Strip ſhould be made *jagged* at its edges, is; that, the Electricity may be able to *diſcharge* itſelf with the *greater facility:* inaſmuch as Electricity is known, both to enter into, and to iſſue out of, Metals, with *greater eaſe,* through Points and ſharp edges, than elſewhere.

The Reaſon for my propoſing, that the above mentioned Strip of Metal, ſhould be *wide,* and ſome *yards* in length, is; in order, that a *greater Quantity of Metal* ſhould be *in contact* with the moiſt Earth, into which the Electricity of the metallick Conductor muſt *diſcharge* itſelf.

The Reaſon for my propoſing, that the Rod, which is made to connect this Strip of Metal, with the lower End of the Conductor that is fixt to the Building, ſhould be *fifteen* or *twenty yards* long, and ſhould be *round,* is; that, the electrical Fire, after having run down the Conductor, ſhould be conveyed to ſuch a Diſtance from the Building, as not to be in danger of damaging its *Foundation;*

and that it ſhould *not* have ſo great a tendency to diſcharge itſelf, into the Earth, *near* the Building, as at a *greater Diſtance* from it.

And laſtly, the Reaſon, for my propoſing that ſuch *Parts* of the Conductor as are *under ground* ſhould be either of *Copper* or of *Lead*, and *not* of *Iron*, is; that, *Iron* when laid under ground is ſubject to great decay; and that the *Ruſt* † of Metals does *not conduct Electricity.*

§ 527. *Fifthly*, the many excellent Things that have been written, at different Times, in different Countries, by very learned and ingenious Men, ſuch as Dr. *Franklin*, Signior *Beccaria*, Mr. *Wilcke*, Mr. *Henly*, Mr. *Le Roy*, Dr. *Ingen-houſz*, Mr. *Archard*, Mr. *Nairne*, &c. have fully convinced the *beſt* Judges on this Subject, that *conducting Rods* ought always to be terminated in very *acute metallick Points*; and I truſt, that what I have ſaid in this Treatiſe, will tend, in ſome meaſure, ſtill more firmly to eſtabliſh the important Truth, that (in order to give the *greateſt Degree of ſecurity* to Buildings), *the upper Extremity, of every metallick Conductor, ought to be made as acutely pointed as poſſible.*

§ 528. *Sixthly*, now, ſince, the admirable Properties of a *metallick Point*, do *not* depend upon its *Form*, but upon its *projecting* beyond the electrified Body or Bodies, to which it is (by a good communication) connected; and alſo, upon the *ſmall Quantity of Surface* which it has *in contact* with the Air, as was explained above, in § 47: it is

evident,

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† See Dr. Prieſtley's, Hiſtory of Electricity, Page 224. 712.

the incomparable

evident, that, in order, for a Rod to have *all ~~the incomputable~~ advantages*, of which, a *very acutely pointed Conductor is ſuſceptible*; it is neceſſary, that ſuch Rod be moreover *very finely tapered* at its upper Extremity. That is to ſay, that, not only the *Vertex* of the Rod ſhould be *exceedingly ſharp*; but, that the *upper End* of the Rod, for ſome way down, ſhould be *very ſmall*; ſo as to form a *Cone* or *Pyramid*, the *Diameter* † *of whoſe Baſe* ſhould bear an *extremely ſmall proportion* to the *Height* of ſuch Cone or Pyramid; as, for inſtance, the *ſmall proportion* of *one* to *forty*. So that, at the Diſtance of *forty inches* from the *Vertex* of the Rod, the *Diameter* of the Rod ſhould not exceed *one inch*; at the Diſtance of *twenty inches*, the *Diameter* ſhould not exceed *half an inch*; at the Diſtance of *ten inches*, the *Diameter* ſhould not exceed *one quarter of an inch*; and ſo on, *in proportion*.

§ 529. The upper *fifteen* or *twenty inches* of the Rod, muſt be of *Copper*, and not of *Iron*; as *Iron*, expoſed to the Weather, would *ruſt*; and *Ruſt* does not *conduct Electricity*.

The *Iron* Part of the Rod may be *painted*: but, the *upper* Extremity of the Rod never muſt; as *Paint* is *no Conductor*.

§ 530. I do not approve of the method, of making the *Point* of a Conductor of *Iron gilt*; Firſt, becauſe *Gilding* does not adhere very well to *Iron*, eſpecially when expoſed conſtantly to the Weather; and Secondly, becauſe the upper End of the Rod, *cannot* be made, *this way*, either ſufficiently *tapering*, or ſufficiently *acute*, which is a capital objection. The moſt *perfect* way poſſible of terminating the upper End of a Conductor, is undoubtedly, to fix neatly, to the Top of the tapering *Copper Part* of the Rod, *a very fine, and exceedingly acute needle of Gold*, projecting half an inch, or more, beyond the *Copper*. The beſt method of fixing this *fine Gold wire*, is, to inſert one End of it, very tight into an exceeding fine hole drilled vertically into the Top of the *Copper* Part of the Rod. In Figure 24, *aa* repreſents the *needle of Gold*, and *bb* repreſents the Top of the *Copper Part* of the Rod, both of their natural Size. The Quantity of *Gold* that this takes, is ſo extremely trifling, that it can never ſenſibly add to the Expence. There is no Method, which I ſhould ſo ſtrongly recommend, as *this*: tho', a *Copper* Termination, ſufficiently *tapering* and ſufficiently *acute*, will anſwer the purpoſe very well.

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† N. B. I have here applied the Word *Diameter*, to the *Baſe* of *Pyramids* in general, for want of a better in our Language.

§ 531. *Seventhly*, it is alſo evident, from what was laid down at the beginning of § 528, and from what was ſaid in § 48, in § 49, and in ſome preceding SECTIONS of PART I; that, the *upper Extremity* of a conducting Rod, muſt not only be *exceedingly acutely pointed*, and *very finely tapered*, but muſt alſo be *extremely prominent*. That is to ſay, that the Rod ſhould extend about *eight*, *ten*, or *fifteen* † Feet, above *all the Parts* of the Building which are the *moſt contiguous* to it.

§ 532.

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† N. B. Two Conductors which I cauſed to be erected, in *Kent*, upon *Chevening* Houſe, extend, each of them, upwards of *ſeventeen Feet*, *above* the Stacks of Chimneys againſt which they are fixed.

§ 532. We have ſeen above (§ 358,) that every *conducting Body*, which is placed within the ſenſible Part of any electrical Atmoſphere (whether that Atmoſphere be charged *in plus* or *in minus*), will neceſſarily tend to become charged, at its Side which is the *neareſt* to the charged Body producing that Atmoſphere, with an Electricity *contrary* to that of the electrical Atmoſphere in which it is immerged.

Therefore, when a Thunder-Cloud approaches towards the Earth, it is evident, that, *that Part* of the Earth which is immediately *underneath*, muſt become charged with an Electricity *contrary* to that of the Cloud. The neceſſary conſequences of which muſt be, that, *that Part* of the Earth, which thus grows charged, will become ſurrounded by an *electrical Atmoſphere*, which will be *contrary* to that of the *Cloud*; agreeably to my Experiments related above.

§ 533. Now, we have ſeen above, † that, it is the *electrical Atmoſphere* round a charged Body which tends to *prevent* ſuch charged Body from becoming *unelectrified*. That is to ſay, in the caſe before us, that, *that Part* of the Earth which becomes charged with the *contrary* Electricity to that of the Cloud, will be prevented, by the *electrical Atmoſphere, which ſurrounds* the *charged Portion* of the Earth that is under the Cloud, from having its natural *Equilibrium* with the Cloud, reſtored.

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† From § 30 to § 49.

§ 534 From the important *Law* which I have demonſtrated above, with reſpect to the *electrical Denſity* of electrical Atmoſpheres; it is evident, that, the *Electricity*, of the *electrical Atmoſphere* which thus ſurrounds the *charged Portion* of the Earth that is under the Thunder-Cloud, muſt *decreaſe in denſity in the inverſe Ratio of the ſquare of the Diſtance* from the Surface of the Earth.

§ 535. Therefore, if any *tapering*, *pointed metallick Conductor*, be made to *project* above the *Surface of the Earth*, or be made to *project* above any very *large conducting Body* whatever (as, for inſtance, a flat Roof of Lead,) raiſed above the Surface of the Earth; it is evident, that, the electrical *ſilent Diſcharge* through the Conductor, will [*cæteris paribus*] be the *ſtrongeſt*, in the Caſe, when the upper Extremity of the Rod *projects the moſt*: inaſmuch, as the *more it projects*, the *more it will be out of the denſe Part*, *of the electrical Atmoſphere*, of that *charged Portion* of the Earth which is under the Cloud.

§ 536. And, from the above-mentioned *Law*, of the *electrical Denſity*, of electrical Atmoſpheres *decreaſing in the inverſe Ratio of the ſquare of the Diſtance* from the charged Body producing ſuch Atmoſphere; it evidently follows; if the conducting Rod *projects*, for example, *twelve feet*; that, the *Denſity of the Electricity*, of the Earth's electrical Atmoſphere, *round* the *metallick Point* of ſuch Conductor, will be *four times leſs*, than if the Rod *projected only ſix feet*; that, it will be *nine times leſs*, than if the Rod *projected only four feet*; that, it will be *ſixteen times leſs*, than if the Rod *projected only three feet*;

that, it will be *thirty ſix times leſs*, than if the Rod *projected only two feet*; that, it will be *ſixty four times leſs*, than if the Rod *projected only one foot and an half*; that, it will be *one hundred and forty four times leſs*, than if the Rod *projected only one foot*; and ſo on, *in proportion*.

I know of nothing, that tends ſo ſtrongly to prove, the *great advantage* that there is, in making *tapering pointed* Conductors *project conſiderably*, as this very circumſtance.

§ 537. *Eighthly*, that the *Rod* ought to be carried in the *ſhorteſt convenient Direction*, from the *Point* at its upper End to the *Common-Stock*, is evident, from the well known Property, which an *electrical Charge* has, of paſſing *that way* where it meets with the *leaſt Reſiſtance*; and conſequently, of *dividing* itſelf, and of *prefering* a *very ſhort* paſſage † through *indifferent* Conductors [or even through the *Air*], to a *long* Paſſage through *Metals*.

From the ſame Principle, it appears, that any *metallick Conductors* (ſuch as metal Water Pipes, &c.) which *communicate* with the conducting Rod, and which reach *near the Earth*, ſhould be connected, by a proper metallick Communication, with the *Common-Stock*.

§ 538. *Ninthly*, that, there ſhould be, neither *large* nor *prominent* Bodies of Metal, upon the Top of the

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† See the very deciſive Experiments that the learned Dr *Prieſtley* has made upon this ſubject, and which he relates in his Hiſtory of Electricity, Pages 689 & *ſeq.*

712

Building propoſed to be ſecured, but ſuch as are *connected with the Conductor*, by ſome proper *metallick Communication*; has been clearly ſhewn by that knowing Electrician Dr. *Ingen-houſz*, in an excellent Paper, which he preſented to the *Emperor*, containing his opinion of the beſt Method of ſecuring Gunpowder Magazines againſt damage by Lightning.

The precaution here-mentioned is eaſy to be taken; and the conſideration of the electrical *returning Stroke* (the nature of which I have explained above) ſtill more fully evinces the utility of ſuch precaution.

§ 539. *Tenthly*, the *Number* of *high and pointed Conductors* neceſſary to ſecure a Building perfectly, muſt depend upon the Size, Form, and Situation of ſuch Building.

Signior *Beccaria* †, to whom the Science of Electricity is ſo highly indebted in a variety of reſpects, is of opinion, that Buildings of much extent, ſhould have *ſeveral high and pointed* Conductors.

§ 540. But, even without this great Authority, the propriety of having *ſeveral* high and pointed Conductors, upon *extenſive* Buildings, muſt evidently appear, from what I have ſaid above (in PART XIII), with reſpect to the moſt *general* MANNER in which, an *high and pointed Conductor* tends to ſecure a Building againſt electrical *Strokes of Exploſion*; namely, by *ſilently diſcharging*

into

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† See Dr. *Prieſtly's* Hiſtory of Electricity, Pages 381 and 382
712

into theEarth, the *Electricity*, of *that Part* of a Thunder Cloud's electrical Atmoſphere, into which, it is *particularly* immerged.

§ 541. The learned and ingenious Dr. *Ingen-houſz* has ſhewn how a *Stroke of Lightning* might, by means of a *Shower of Rain* or *Hail*, be *conducted*, from the Clouds, to *one* Extremity of a large Building, tho' the *other* Extremity of the Building were properly ſecured by a Conductor. This circumſtance tends ſtrongly to prove the utility, of having *ſeveral* acute and prominent Conductors, upon *extenſive* Buildings.

§ 542. Conſequently, the *higheſt Parts* of a Building, the *moſt elevated Ridges*, all the *very prominent* Stacks of Chimneys, and all the *moſt ſalient* Angles, ought, in order for the Building to acquire the greateſt degree of *ſecurity*, to be armed with an *high, tapering and acutely pointed metallick Conductor*, properly connected with the Common-Stock. And, upon Edifices of great importtance (eſpecially Magazines of Gunpowder), the *pointed Conductors* ought never to be above *forty* or *fifty feet* aſunder; and if they were to be at ſtill *ſmaller* Diſtances aſunder, the Security they would afford would be ſtill more *perfect*.

§ 543. And *eleventhly*, that every Part of the conducting Rods be very *ſubſtantially erected*, is almoſt too evident to be neceſſary to be mentioned: but, the chief Reaſon for my doing it, is, that I have ſeen abroad, a metallick Rod, ſupported by a *Pillar of Glaſs*, blown down in a violent Storm of Wind. Such Conductors, as are *not* intended for *Experiments*, but, ſolely for *ſecuring* Buildings againſt damage by Lightning, do *not require* to be ſupported upon *Glaſs* or any other *non-conductor*. They *may* however be ſupported upon proper kinds of *non-conductors*, with great advantage.

§ 544. Now, leaſt any thing I have ſaid, in the foregoing Pages, ſhould happen to be miſunderſtood, I think it neceſſary to add; that, I do not abſolutely deny all *poſſibility* of an *high and pointed Conductor* being ſtruck, but I maintain it to be a thing which is *moſt highly improbable* in every reſpect; and that, *even ſhould it happen*, *no Damage* could be done to the Building by ſuch Stroke of Lightning, if the Rod were of a *ſufficient thickneſs*, and were *properly* erected.

But, I have never been able to hear of a *ſingle* Inſtance (nor do I believe that any can be produced), of an *high, tapering and acutely pointed metallick Conductor* having ever, in any Country, *been ſtruck by Lightning*, if it had *all* the *neceſſary Requiſites* that have been explained in this PART XIX, and eſpecially the *ſecond* and *fourth Requiſites* above particularly deſcribed.

P A R T XX.

SECTION 545.

DIVERS admirable Advantages, of *elevated and acutely pointed metallick Rods*, have been demonſtrated already; but, the moſt excellent, and (perhaps) the moſt wonderful, of *all* the Properties, of ſuch *high and pointed Conductors*, ſtill remains to be explained.

§ 546. It may appear a *Paradox*, but yet I hope to prove the Propoſition to be *true*; that, *high and pointed Conductors* [properly erected,] will tend to *ſecure*, both Perſons and Buildings, againſt the above-mentioned bad Effects from natural Electricity, *in the moſt effectual Manner, when the Clouds are the moſt powerfully charged with the Matter of Lightning*: that is to ſay, in that very Caſe, in which, *were it not for ſuch high and pointed Conductors*, there would be *the moſt Danger* to ſuch Perſons and Buildings.

This is a wonderful Circumſtance, in favour of *elevated and acutely pointed* metallick Rods, which is, in my opinion, of the higheſt importance; tho', it has never yet (I believe, by any Perſon,) been at all attended to.

§ 547.

§ 547. In order to make *this* diſtinctly underſtood, it is neceſſary to premiſe, that, very *violent Strokes of Lightning* do invariably come, from *much more conſiderable Diſtances*, than very *moderate ones*. The reaſon of which, is ſimply this.

§ 548. When a Cloud, whether great or ſmall, contains but a *ſmall Quantity* of Electricity; the *denſe Part* of the Electricity, contained in the electrical Atmoſphere of ſuch a Cloud, *cannot* be of any very *great extent*.

Now, we have ſeen above (§ 29), that, it is the *denſe Part* of the Electricity, contained in an electrical Atmoſphere, which cauſes that *electrical Atmoſphere*, to become a *ſudden Conductor* of the *electrical Charge*, to a *given Diſtance* from the Cloud producing ſuch electrical Atmoſphere.

§ 549. Therefore; ſince, the *denſe Part* of the Electricity, contained in the electrical Atmoſphere of a Cloud that is *weakly charged*, *cannot* extend to any very *great Diſtance*; it is evident, that the *ſtriking Diſtance*, of a Cloud *weakly charged*, *cannot* be of any very *great extent*.

That is to ſay, that, a Cloud *weakly electrified*, muſt neceſſarily approach *near* the Earth, before it can *diſcharge*, *with an Exploſion*, its Electricity, upon any Body placed on the Surface of the Earth.

§ 550. Whereas, when a Cloud is *very powerfully electrified*; the *denſe Part* of its electrical Atmoſphere, will extend to a *prodigious Diſtance*. The conſequence of which is, that, the *ſtriking Diſtance*, of a Thunder Cloud *very powerfully charged*, muſt be of a *vaſt extent.*

§ 551. It is, therefore, *impoſſible*, that a Thunder Cloud *very powerfully electrified*, [ſhould *ſtrike*, in the *firſt inſtance*; that is to ſay,] ſhould *ſtrike*, in *full force*, at any *ſmall*, or even *moderate*, *Diſtance* from the Earth. Inasmuch as ſuch a Cloud muſt, of neceſſity, *diſcharge, with an Exploſion*, the greateſt Part of its Electricity, *before it comes* to ſuch *ſmall*, or even *moderate*, *Diſtance.*

§ 552. I do *not* aſſert, that the *Force of an electrical Diſcharge* from a Thunder-Cloud, is always as ſome *direct Function* of the *Length* † *of the ſtriking Diſtance*: for, I can

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† It is proper to take notice, in this place, of the neceſſity there is, to pay particular attention to *all the circumſtances* attending any Experiments made upon the proportional *Length* and *Force*, of Sparks or Strokes in Electricity; in order, to avoid falling into the greateſt Errors, that could poſſibly be adopted.

Every One knows, for inſtance, the *immence Difference* that there is, between the *Force* of a *long Spark* taken from a common *Prime-Conductor*, and the vaſt *ſuperior Force* and *Pungency* of a *much ſhorter Spark* taken from a *Leyden Jar*. Nay, there is a variety of ſuch *Differences*, even in electrical Machines, that are more *ſimilar* in their nature; ſuch as *ſingle*, and *double*, *Prime-Conductors*; and ſuch as *ſingle Leyden Jars*, and *Leyden Batteries*. For, the *Length* of the Spark (for inſtance,) from a *large Battery*, compoſed of many *Lyden Jars*, is often *not near ſo great*, as the *Length* of the Spark taken from only *one* of thoſe ſame Jars; tho', the *ſtrength* of the Shock, occaſioned by the *Battery*, is ſo *vaſtly ſuperior* to that, occaſioned by the *ſingle Jar*.

I ſhall defer the diſcuſſion and explanation of theſe Things to my propoſed Treatiſe on *Leyden Jars*, &c. I will, therefore, only ſay, in this place, that, in making Experiments, or in reaſoning, upon the relative *Length* and

I can conceive, that, the Size, Shape, Denſity, relative Charge, and particular Situation, of different Clouds, [together with the particular Circumſtances, by which, their electrical Atmoſpheres might be affected,] may cauſe *this*, in ſome Degree, † to vary. But, I believe, that there is *not*, in the World, any Electrician, (or any Man who pretends to be an Electrician,) who will conteſt the Truth of the *general Propoſition* I have here laid down; *viz.*

That, very *violent Strokes of Lightning*; namely, *ſuch* as proceed from Clouds, which are the *moſt powerfully electrified* [whether *in plus* or *in minus*]; muſt invariably come from a *prodigious Diſtance.* And that, *moderate Strokes of Lightning*; namely, *ſuch* as proceed from Clouds, which are but *weakly electrified* [whether *in plus* or *in minus*]; *cannot* come, to the Earth, from *near ſo conſiderable* †† *a Diſtance.*

§ 553. Now, let us ſuppoſe, that there be *two* Thunder-Clouds; the *one*, very *powerfully charged* with Electricity, which (for diſtinctneſs) I will call C; and the *other*, but *weakly charged*, which I will call *c*.

That

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and *Force*, of electrical Sparks or Strokes; none but Magazines of Electricity, of the *ſame* kind, and of *ſimilar* attributes, ought to be compared together. So that, the *Strokes*, from *ſingle Prime-Conductors* [of *ſimilar* Forms], from *ſingle Electrophori*, from *double Prime-Conductors*, from *double Electrophori*, from *Leyden Plates*, from *Leyden Jars*, from different kinds of *Leyden Batteries*, &c. and from *Thunder-Clouds* differently circumſtanced, ought always to be *reſpectively* compared, with electrical *Strokes* of the *ſame Claſs*.

† I have reaſon to think, that the Clouds being *negatively* [inſtead of *poſitively*] electrified, will produce a *difference* in the above-mentiond reſpect.

†† N. B. It is upon a ſimilar Principle, that the ingenious *Electrometer* of Mr. *Lane* F. R. S. is founded. The deſcription of this Electrometer is given, in the Philoſophical Tranſactions, Volume 57, Page 451 & *ſeq.*

That Part, of the *powerfully electrified* Cloud C's electrical Atmoſphere, which is *juſt at the Limit of the natural* † *ſtriking Diſtance*, of that Cloud C; I will call L.

And *that Part*, of the *weakly electrified* Cloud *c's* electrical Atmoſphere, which is *juſt at the Limit of the natural ſtriking Diſtance*, of that Cloud *c*; I will call *l*.

§ 554. Let us ſuppoſe, that there be a *good metallick Conductor*, properly connected with the Common-Stock, and terminated, at its upper Extremity, in a very *prominent, tapering and acute metallick Point*; and let us examine, whether the *greateſt Degree of Security* would be derived, from the *action of ſilent Diſcharge*, through ſuch *acute metallick Point*, in the Caſe of the very *powerfully electrified Cloud* C, or in *that* of the *weakly electrified Cloud c*, above-mentioned.

§ 555. Firſt, it is evident, from the *Principles of Electricity* ſo fully laid down in the foregoing Pages; that, the *Quantity of ſilent Diſcharge*, through a good metallick Conductor, properly connected with the Earth, and whoſe upper Extremity is *given*, in *prominency*, in *acuteneſs*, and in *poſition*, muſt [*cæteris paribus*] be *proportional*, to the elaſtick *electrical Preſſure*, of the electrical Atmoſphere, *ſuperinduced* upon the *given Point* of ſuch metallick Conductor.

§ 556.

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† When I make uſe of the Expreſſion, of the *natural ſtriking Diſtance*, of a Thunder-Cloud, or of any other charged Body; I always mean to ſpeak of the *greateſt Diſtance*, to which, ſuch electrified Cloud, or ſuch charged Body, is able to *ſtrike* upon any *given* conducting Body; before the *ſtriking Diſtance* is, by any means, diminiſhed.

§ 556. But, the elaſtick *electrical Preſſure*, of an electrical Atmoſphere, *ſuperinduced* upon a *given metallick Point*, is neceſſarily *proportional* to the *Denſity of the ſuperinduced Electricity*.

§ 557. Therefore, the *Quantity of ſilent Diſcharge*, through a *given metallick Point*, muſt [*cæteris paribus*] be *proportional* to the *Denſity of the ſuperinduced Electricity*.

§ 558. Now, the *greater the Diſtance*, from any charged Cloud, is; the *better*, it is requiſite, that *the Conductor*, between ſuch Cloud and the Earth, ſhould be; in order, for ſuch Conductor to be able *ſuddenly to convey*, the *Charge* of ſuch electrified Cloud, to Bodies on the Surface of the Earth.

§ 559. But, we have ſeen above, in SECTION 390; that, it is the *Electricity* itſelf, which is contained in an electrical Atmoſphere, that cauſes ſuch *electrical Atmoſphere* to become a *ſudden Conductor* of an *electrical Charge*, to any *given Diſtance* from the electrified Cloud (or other charged Body) producing ſuch electrical Atmoſphere.

§ 560. Conſequently, the *greater the Diſtance*, from any charged Cloud, is; *the greater*, *it is requiſite*, *that the Denſity*, *of the ſuperinduced Electricity*, ſhould be; in order, for it to be able *ſuddenly to convey* the *Charge* of ſuch electrified Cloud, to Bodies on the Surface of the Earth.

That is to ſay, in other Words, that, in the Caſe before us; it is requiſite, that, *the Denſity of the ſuper-induced Electricity* ſhould be *greater* at L, in order, for the *powerfully electrified Cloud* C, to *ſtrike* as far as L; than, it is requiſite, that, *the Denſity of the ſuperinduced Electricity* ſhould be at *l*, in order, for *the weakly electrified Cloud c*, to *ſtrike* as far as *l*.

§ 561. Now, we have ſeen above (in § 557), that the *Quantity of ſilent Diſcharge*, through a *given metallick Point*, muſt [*cæteris paribus*] be *proportional* to the *Denſity of the ſuperinduced Electricity*.

Therefore, it is evident, that, in the Caſe before us; the *Quantity of ſilent Diſcharge*, through the *given metallick Point*, would [*cæteris paribus*] be *greater*, from *the Part* L of the electrical Atmoſphere of the *powerfully electrified Cloud* C; than, it would be, from *the correſponding Part l* of the electrical Atmoſphere of the *weakly electrified Cloud c*.

And, it is moreover evident, that, ſuch *Quantity of ſilent Diſcharge*, through the *given metallick Point*, would be, as much *greater* at L, than it would be, at *l*; as the *Denſity of the ſuperinduced Electricity* at L, is *greater* than the *Denſity of the ſuperinduced Electricity* at *l*.

§ 562. That is to ſay, that, *the given metallick Point* would, when at L, cauſe, during any ſhort *given Time t*, a *greater* real DEFICIENCY, in the *Quantity of the Electricity*, which is contained in the *ſuperinduced electrical Atmoſphere* of the *powerfully charged Cloud* C, and which is *requiſite* in that electrical Atmoſphere, in order to enable that *powerfully charged Cloud* C, to *ſtrike* as far as L;

as L; than ſuch *given metallick Point*, when at *l*, would, during the *ſame* ſhort *given Time t*, cauſe, in the *Quantity of the Electricity*, which is contained in the *ſuperinduced electrical Atmoſphere* of the *weakly charged Cloud c*, and which is *requiſite* in that electrical Atmoſphere, in order to enable that *weakly electrified Cloud c*, to *ſtrike* as far as *l*.

And it is evident, that, the *electrical Deficiency* produced at L, by the *given metallick Point*, during the ſhort *given Time t*; muſt be, to the *electrical Deficiency* produced at *l*, by the *ſame given metallick Point*, during the *ſame* ſhort *given Time t*; in the *ſame Ratio*, as the *Denſity of the ſuperinduced Electricity* at L, is to the *Denſity of the ſuperinduced Electricity* at *l*.

§ 563. Now, it is moſt evident, that, the ſaid *electrical Deficiencies* do reſpectively repreſent the *Quantities of Electricity*, that muſt neceſſarily be *ſupplied* to the reſpective *electrical Atmoſpheres ſuperinduced*, in order, for the above-mentioned *given metallick Point* to be *ſtruck*.

That is to ſay, that, the *Quantity of Electricity*, which it is *requiſite* ſhould, during any ſhort *given Time t*, be *ſupplied*, to the electrical Atmoſphere *ſuperinduced* upon the *given metallick Point* at L, in order, for ſuch *given metallick Point* to be *ſtruck* from the *powerfully charged Cloud* C; muſt be, as *much greater*, than the *Quantity of Electricity*, which it is *requiſite* ſhould, during the *ſame* ſhort *given Time t*, be *ſupplied*, to the electrical Atmoſphere *ſuperinduced* upon the *given metallick Point* at *l*, in order, for ſuch *given metallick Point* to be *ſtruck* from the *weakly charged Cloud c*; as the *Denſity of the ſuperinduced Electricity* at L, is *greater* than the *Denſity of the ſuperinduced Electricity* at *l*.

§ 564. Conſequently, the *given metallick Point*, when at L, will [*cæteris paribus*], by means of its gradual Operation of *ſilent Diſcharge*, tend, in the reſpect above mentioned, *more ſtrongly*, in any ſhort *given Time t*, *to prevent* an electrical *Stroke of Exploſion* from taking place, from the *powerfully charged Cloud* C; than, ſuch *given metallick Point* would, when at *l*, tend, in the *ſame* ſhort *given Time t*, to *prevent* an electrical *Stroke of Exploſion* from taking place, from the *weakly charged Cloud c*; as, from the clear and important *Principles* ſo fully laid down in PART XIII of this Treatiſe, muſt evidently appear.

§ 565. The *electrical Atmoſphere* of any *powerfully charged Cloud* C, muſt always (agreeably to what has been ſtated above), of neceſſity, extend to a *greatly ſuperior Diſtance*, than the *electrical Atmoſphere* of any *weakly charged Cloud c*.

Therefore, if the *two Clouds* C and *c*, approach towards any *pointed metallick Conductor* upon the Surface of the Earth, with any *given Velocity v*; it is evident, that, the *Time* of the *given metallick Point*'s action of *ſilent Diſcharge* upon the ſuperinduced electrical Atmoſphere of the *powerfully charged Cloud* C, muſt nearly [*cæteris ſimilibus*] be, as much *greater* than the *Time* of the *ſame given metallick Point's* action of *ſilent Diſcharge* upon the ſuperinduced electrical Atmoſphere of the *weakly charged Cloud c*; as the *Extent* of the electrical Atmoſphere of the *powerfully charged Cloud* C, is *greater* than the *Extent* of the electrical Atmoſphere of the *weakly charged Cloud c*.

§ 566. Now, we have ſeen (in § 564), that a Conductor, terminated in a *prominent acute metallick Point*, would tend *more ſtrongly*, even in a ſhort *given Time*, to *prevent* an electrical *Stroke of Exploſion* from taking place from a *powerfully charged Cloud* C; than, ſuch *given metallick Point* would, in the *ſame* ſhort *given Time*, tend to prevent an electrical *Stroke of Exploſion* from taking place from a *weakly charged Cloud c*.

Therefore, in the Caſe before us, it is evident, that, the *given metallick Point*, by having a *long Time* to act upon the ſuperinduced electrical Atmoſphere of the *powerfully charged Cloud* C, muſt [*a fortiori*] tend, in the reſpect above-mentioned, *more powerfully*, to *prevent* an electrical *Stroke of Exploſion* from taking place from that *powerfully charged Cloud* C; than, ſuch *given metallick Point* would, by having a much *ſhorter Time* to act upon the ſuperinduced electrical Atmoſphere of the *weakly charged Cloud c*, tend to *prevent* an electrical *Stroke of Exploſion* from taking place from that *weakly charged Cloud c*.

§ 567. It is a well-aſcertained *Fact*, † that *Clouds can never be the moſt powerfully charged with the Matter of Lightning*, except in the Caſe, when the *Air* is the *moſt free from Moiſture*.

§ 568.

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† The Reaſons of the above *Fact*, are ſimply theſe.

1*ſt*. Becauſe, when the *Air is damp*, the Clouds *cannot acquire* ſo *great* a Degree of Electricity; as they can, when the *Air* is *dry*.

And 2*ndly*.

§ 568. Now, when, during a Thunder-Storm, the Air is the *moſt free from Moiſture*; that is to ſay, when the *electrical Atmoſphere*, of the Thunder-Clouds, is the beſt *non-conductor of Electricity*; if any *Electricity* be *gradually* and *ſilently diſcharged* from a Thunder-Cloud's *electrical Atmoſphere*; it is evident, that, it muſt *require* a *much longer Time*, [††] for ſuch Electricity to be *reſtored*; than, it would *require*, if the *Air* was *damp*: that is to ſay, than it would *require*, if the Thunder-Cloud's *electrical Atmoſphere* was *not* a good *non-conductor of* Electricity.

§ 569. That is to ſay, in other Words, that there is *no Caſe* whatever, in which, any *Electricity*, that is *gradually* and *ſilently diſcharged* from a Thunder-Cloud's *electrical Atmoſphere* [by means of an *high and acutely pointed*

And 2ndly: Becauſe, even if it were poſſible, that *Clouds*, when the *Air* is *damp*, could *acquire* any very *ſtrong given Charge of Electricity*; ſuch *given Charge* would, before the Thunder-Cloud could come within a *ſtriking Diſtance* of the Earth, be, *cæteris paribus*, much *ſooner diſſipated*, [that is to ſay, the *natural electrical Equilibrium*, between the Cloud and the Earth, would be much *ſooner* ſilently reſtored,] when the *Air is damp*; than, it would be, when the *Air* is more *free from Moiſture*.

N. B. It is for theſe Reaſons, that [generally ſpeaking] there is *not near ſo much Danger from Lightning*, when the *Air* is *damp*; as there is, when the *Air* is extremely *dry*.

[††] We have not as yet any electrical Inſtruments, that are proper for the meaſuring of *this Difference*; but, it is evident, that it muſt be *proportional* to the *Time*, which electrified Bodies take to loſe any given Charge of Electricity; which *Time* (every one knows) is ſo vaſtly *greater*, when the *Air is dry*, than when the *Air is damp*. We have to expect ſome very intereſting Experiments upon this ſubject, from the learned Signior *Fontana*, who has already diſtinguiſhed himſelf ſo much in the inveſtigation of the Laws of Nature.

pointed metallick Conductor], would *require a longer Time*, in order to be *reſtored*; than, in the Caſe, when ſuch Thunder-Cloud is the *moſt powerfully charged with Electricity*: inaſmuch, as ſuch Clouds as are the *moſt powerfully charged*, are always ſurrounded by an *electrical Atmoſphere* which muſt neceſſarily be a good *non-conductor of Electricity*.

§ 570. Now, I have demoſtrated above (§ 562), that, a *given metallick Point* would [*cæteris ſimilibus*] cauſe, during any ſhort *given Time*, a *much greater* real DEFICIENCY, in the *Quantity of Electricity*, which is contained in the *ſuperinduced electrical Atmoſphere* of a Cloud *powerfully charged*; than, ſuch *given metallick Point* would (in like manner), during the *ſame* ſhort *given Time*, cauſe in the *Quantity of Electricity*, which is contained in the *ſuperinduced electrical Atmoſphere* of a Cloud that is but *weakly electrified*.

I have alſo proved above (§ 565), that, a *given metallick Point* muſt [*cæteris ſimilibus*] exert *much longer* its action of *ſilent Diſcharge*, upon the *ſuperinduced electrical Atmoſphere*, of a Cloud *powerfully charged*; than, upon the *ſuperinduced electrical Atmoſphere* of a Cloud that is but *weakly charged*.

I have moreover juſt ſhewn (§ 569), that, there is *no Caſe* whatever, in which, any *Electricity*, that is *gradually* and *ſilently diſcharged* from a Thunder-Cloud's *electrical Atmoſphere* [by means of an *high and acutely pointed metallick Conductor*], would *require a longer Time*, in order to be *reſtored*; than, in the Caſe, when ſuch Thunder-Cloud is the *moſt powerfully charged with Electricity*.

And I have likewiſe fully explained, in the foregoing Pages (§ 390), that, it is the *Electricity* itſelf, contained in the *electrical Atmoſphere* of a Thunder-Cloud, that enables ſuch *electrical Atmoſphere* to *conduct* any electrical *Stroke of Exploſion*, to Bodies on the Surface of the Earth.

§ 571. Conſequently, from theſe Propoſitions, it muſt appear evident; that, a *metallick Conductor*, properly erected, and terminated at its upper Extremity in a very *prominent and acute metallick Point*, has the peculiar, important, ſurprizing and moſt excellent Property, of tending *even* MORE POWERFULLY to prevent an electrical *Stroke of Exploſion* from happening, near the Place of *ſilent Diſcharge*, in the Caſe, when the Clouds are the *moſt ſtrongly charged*, than, when they are but *weakly charged*, with the *Matter of Lightning*.

Here, we may perceive, not only the Direction of DIVINE *Wiſdom*, but the *Goodneſs* of PROVIDENCE towards Mankind, in having ſo admirably ſettled *all* theſe Things, in the ſublime arrangement of the World, that, it ſhould be in the *power of* ~~*Man*~~‸ to *ſecure* Themſelves and their Habitations, againſt the above-mentioned dire Effects of natural Electricity, *in ſuch a Manner*, that there ſhould be the *ſmalleſt* Danger to be apprehended, when there is the *greateſt Quantity* of electrical Fire in the Clouds; and that there ſhould be the *leaſt* Probability of the Lightning falling, in thoſe *very caſes*, in which, if it *did fall*, the inevitable Conſequences would be the *moſt* deſtructive, the *moſt* fatal, and the *moſt* tremendous.

‸ Mankind

APPENDIX.

APPENDIX.

SECTION 572.

LEST ſome things I have ſaid, in the foregoing Pages, ſhould happen to be miſunderſtood; I have judged it proper, for the ſake of greater perſpicuity, to ſubjoin this APPENDIX, which will, I hope, prevent any Propoſitions, of which I ſhall here give a more detailed Explanation, from being any-wiſe miſconceived; however conciſely ſuch Propoſitions may have been expreſt above.

SECTIONS 7 and 8, explained.

§ 573. As the *Truth* of all the moſt important Propoſitions which I have laid down above, depends upon the Exiſtence of *electrical Atmoſpheres* around Bodies charged with Electricity [whether *in plus*, or *in minus*]; and as *our Knowledge* of the Truth of ſuch general Propoſitions, muſt neceſſarily depend upon our having a juſt and true Idea of ſuch *electrical Atmoſpheres*; I have endeavoured to prove,† that, it is the *Particles of (circumambient) Air being electrified*, that conſtitutes the *electrical Atmoſphere* which exiſts around charged Bodies.

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† See § 19.

§ 574. I have ſaid above [in § 7, and in § 8], that, the Air which ſurrounds a Body electrified *in plus*, will, by coming *into contact* with ſuch *poſitive* Body, form around it, an electrical *Atmoſphere* which will likewiſe be *poſitive*. And that, the Air which ſurrounds a Body electrified *in minus*, will, by coming *into contact* with ſuch *negative* Body, form around it, an electrical *Atmoſphere*, which will likewiſe be *negative*.

Theſe Propoſitions are univerſally true: but, I do *not* thereby mean to convey (as muſt evidently appear from ſeveral other Parts of this Treatiſe), that, *no Particles of Air* can become electrified, except ſuch as come into immediate *contact* with the charged Body itſelf; for, all *unelectrified* Particles of Air, which come *ſucceſſively* into contact with any *Particles of Air* that are become electrified, [whether *in plus* or *in minus*], will thereby acquire a certain degree of the *ſame* kind of Electricity.

§ 575. When the *Air is damp*; then, not only the *Air* itſelf, which ſurrounds a charged Body, will become electrified; but, the *aqueous Vapour*, contained in that Air, will alſo acquire Electricity, and will [by being a bad *non-conductor*] convey ſuch Electricity away in *great* Quantities; and it is for this Reaſon, that an electrified Body, ſurrounded by *damp Air*, becomes ſo *ſpeedily diſcharged*.

§ 576. It may perhaps be thought, that the Electricity of a charged Body does *not diffuſe itſelf* into the circumambient Air; but, that it actuates ſuch Air, by exciting either a *tenſion* or a *relaxation* in the natural Fire inherent in it. This is undoubtedly a very ingenious Hypotheſis, which ſeveral natural *Phenomena* appear to favour; but, I truſt I ſhall have it in my power, at ſome future time, more fully to eſtabliſh the Truth of what I have here laid down, with reſpect to *electrical Atmoſpheres* conſiſting of *common Air* that has acquired [either *poſitive* or *negative*] Electricity.

SECTIONS 12, 19, and 20, explained.

§ 577. I have related, in § 12, my having cauſed a pair of electrometrical Balls, ſuſpended in the Glaſs Receiver of an Air-Pump, to divaricate, by cauſing a ſmall charged Prime-Conductor to communicate with the braſs cap of the Receiver: but, I omitted to mention, that, that Prime Conductor was electrified *in plus*; that is to ſay, that, my *four* firſt Experiments were performed, with *poſitive* Electricity only. I have however, in § § 19 and 20, concluded *generally*, that, an *electrical Atmoſphere*, whether *negative* or *poſitive*, conſiſts of electrified *Air*. The Reaſon, for my having drawn ſuch *general* Concluſion, is as follows.

§ 578. Previous even to my having made any electrical Experiments with an exhauſting Receiver, I had imagined, that, it was the *Particles of* [*circumambient*] *Air being electrified*, which conſtituted the *electrical Atmoſphere* exiſting around every Body charged with Electricity.

With reſpect to a *negative Atmoſphere*, this appeared to me to be particularly evident.

§ 579. I reaſoned thus:

"It is (perhaps) *not* impoſſible in nature, for a *poſitive* "electrical *Atmoſphere* to be formed, where there is *no* "*Air*; inaſmuch as it is (perhaps) *no* contradiction to ſay, "that the Fluid *Electricity*, may be introduced into a "Space exhauſted of the Fluid *Air*. But, it is an "abſolute abſurdity to ſuppoſe, that a *negative* electrical "Atmoſphere ſhould exiſt in a *vacuum*; inaſmuch as it "is impoſſible, for a *non-entity*, which naturally con- "-tains *no electrical Fluid*, to be *deprived of that* which "it does *not contain*".

"Since, then, a *negative* electrical *Atmoſphere* muſt "depend upon the *preſence of Air*; and ſince, Nature "always appears to obſerve *ſimilar Laws*, with reſpect to "*ſimilar Subjects*; there is ſtrong reaſon to think, that a "*poſitive* electrical *Atmoſphere* muſt depend alſo upon the "*preſence of Air*.—Let the Experiment be made."

§ 580. Accordingly, I made the Experiment, with *poſitive* Electricity (as related in PART I); and I found my Suppoſition verified.

It was quite unneceſſary, to make any ſimilar Experiment with *negative* Electricity; ſince, it was, *a priori*, evident, that, a *negative* electrical *Atmoſphere* muſt depend upon the *preſence of Air* negatively electrified.

SECTION 29 illuſtrated.

§ 581. I think there is no Principle, in Electricity, of greater importance, (tho' I believe it was never before diſcovered,) than *that*, which is ſtated in SECTION 29;

namely, that, it is the *Electricity* itſelf, contained in an *electrical Atmoſphere*, which ſerves *ſuddenly to conduct*, to a given Diſtance, any given electrical *Charge*.

This Principle has been ſo frequently mentioned and exemplified in other Parts of this Work, that it appears to me unneceſſary to enlarge upon it. But, there is a curious *Phenomenon* which deſerves to be here mentioned; ſince, it tends ſtrongly to illuſtrate this Principle. This *Phenomenon* is as follows.

EXPERIMENT 62.

§ 582. Charged Bodies will generally *not ſtrike* at the *greateſt* Diſtance, at which, they will *finally* be able to diſcharge, upon a *given* Body, their Electricity with an Exploſion; till *after* they have been made to *ſtrike*, upon the *given* Body, at ſome *ſmaller* Diſtance. This Effect is particularly remarkable, in *ſtrong* electrical Machines.

I have obſerved, for example; when my large Prime Conductor (which, excluſive of its metal Neck and Ball, is about nine feet eight inches in length, by upwards of ten inches in diameter,) was *not* able to be made to *ſtrike*, upon a *round* braſs Body, at the Diſtance of even *thirteen Inches*, if the *round* braſs Body was *not previouſly* placed *nearer* to the Prime-Conductor, than that Diſtance of *thirteen Inches*; that, I could, nevertheleſs, cauſe that Prime-Conductor to *ſtrike*, upon the ſame *round* braſs Body, at the Diſtance of full *fourteen Inches*, provided that Prime-Conductor were *firſt* made to *ſtrike* upon that *round* Braſs Body at the Diſtance (for inſtance) of *twelve Inches*, and were then gradually removed to the above-mentioned Diſtance of *fourteen Inches*.

This is to be accounted for, on the above-mentioned Principle, as follows.

§ 583. Every *electrical Spark* which paſſes through the Air, communicating thereto, *ſome* Electricity; it is a certain Portion of ſuch *Electricity*, when added to the *Electricity*, contained in the electrical Atmoſphere formed around the Prime-Conductor (upon that Prime-Conductor becoming again charged), that enables that *electrical Atmoſphere* ſuddenly to *conduct* the Charge of the Prime Conductor, to the Diſtance of *fourteen Inches*; tho' the *electrical Atmoſphere* of the Prime-Conductor was, before, *not* able to *conduct* the Prime-Conductor's electrical Charge, as far even as *thirteen Inches*.

SECTION 53 referred to.

§ 584. We have ſeen, in SECTION 53, that *nine metal Points*, which Mr. *Archard* made uſe of, did *not* ſilently *diſcharge*, in a given Time, ſo *great a Quantity* of electrical Fluid, from a charged Prime Conductor, as *one* of the ſame nine Points (ſimilarly ſituated) did. But, *no* objection ought to be drawn from thence, to the erecting upon a Building *ſeveral high and pointed Conductors*, as recommended in PART XIX; inaſmuch as Mr. *Archard's nine Points* were almoſt *cloſe* together, being all *nine* fixed at once upon a ſmall circular braſs Plate of only *one Inch* diameter. Therefore, it is evident, from what is alluded-to in § 54; that, *this* Caſe of the *nine Points*, has no kind of relation to the other; namely, to *that* of *ſingle high and pointed Conductors* being erected upon *different* Parts of an extenſive Building.

SECTIONS 60 and 68, referred to.

§ 585. In SECTIONS 60 and 68, I ought to have ſaid, that, the Electricity of the Body AB, was prevented from leaving that inſulated Body, *not only* becauſe the *dry Air* round about, was a *non-conductor* of Electricity, but *alſo* becauſe the *poſitive* End, of that Body AB, was become *immediately ſurrounded*, (in the manner explained § 31, § 32, and § 33,) by an electrical Atmoſphere containing *poſitive* Electricity. Fig. 9.

In like manner, the *negative* End, of that Body AB, was prevented from receiving Electricity, *not only* becauſe the *dry Air* round about, was a *non-conductor* of Electricity, but *alſo* becauſe that *negative* End was become *immediately ſurrounded* (in the manner explained in § 39, § 40, and § 41,) by an electrical Atmoſphere containing *negative* Electricity.

SECTION 82 referred to.

§ 586. I have ſaid in SECTION 82, that, when the electrometrical Ball was brought oppoſite to the Point D, that electrometrical Ball, repreſented at G, appeared to waver, and was neither *repelled* nor *attracted* by the metallick Body AB. It may perhaps be alledged, that, that ſimple Electrometer is ill-repreſented, at G, in Figure 9: but, it was *not* poſſible, in that Figure, to repreſent it quite correctly; inaſmuch as the proper way of making my *Eight Experiment*, is that, which is mentioned at the *End* of § 82; *viz.* by holding the electrometrical Ball G (*not over*, but) on *one ſide* of, the Body AB. Fig. 9.

SECTIONS

SECTIONS 100, 101 and 102, explained.

§ 587. Having, in SECTION 100, and alſo in other Parts of this Work, ſpoken of the *Quantity of Electricity contained* in particular Parts of certain Bodies; I think it proper to remind the Reader, of the important Propoſition, diſcovered by Dr. *Franklin*; namely, that the *plus* [or *minus*] Electricity *contained* in a conducting Body, reſides *entirely on the external Surface* of ſuch conducting Body; and alſo of the judicious diſtinction, made by Signior † *Beccaria*, between common *preſſing* Electricity, and the *vivid* Electricity of a Spark; namely, that the *latter* condenſes itſelf, for an inſtant, *within the pores* of Bodies, and endeavours to break the coheſion of their ſolid Parts; but, that, in *preſſing* Electricity, any *exceſs* of Fire, or any *deficiency* of the ſame, does *not*, in the leaſt, diffuſe itſelf into the *Subſtance* of Bodies.

§ 588. This explains the Reaſon, why the *Baſe* of the *plus* Electricity, and the *Baſe* of the *minus* Electricity, in a *trebly-electrified* Body is *common*, as mentioned in SECTION 102; inaſmuch, as that *Baſe* is the *Line*, where thoſe two *contrary* Electricities, of ſuch Body, *meet* and *join* each other, upon the *Surface* of ſuch Body.

§ 589.

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† See Signior *Beccaria's* learned and ingenious Treatiſe on *Artificial Electricity*, No. 456.

§ 589. From the above-mentioned Propoſition in Electricity, that, the *Quantity of plus* [or the *Quantity of minus*] *Electricity, contained in a Body, reſides entirely on the external Surface of the Body*; it is evident, that the *mean Denſity* of the *plus* [or of the *minus*] *Electricity* of a Body, is *directly* as the *Quantity of Surface* contained in the *poſitive* [or in the *negative*] Portion, multiplied into the *particular Denſity* of the *plus* [or of the *minus*] *Electricity*, at *each Point* of that *poſitive* [or of that *negative*] Surface.

It is likewiſe, in a ſimilar manner, evident; that, the *Quantity*, and *Power*, of *ſuperinduced Electricity*, is *(cæteris paribus) directly* as the *Quantity of Surface* upon which ſuch Electricity is *ſuperinduced.*

Theſe Things elucidate the Propoſitions laid down in § 101, in § 102, &c; and ſhew, that ſtill more comprehenſive Propoſitions may be founded on like Principles.

SECTIONS 150 & *ſeq.* referred to.

§ 590. In making my *Fifteenth Experiment*, upon the *neutral* or *unelectrified Point*; in order to aſcertain, with the greateſt poſſible preciſion (as mentioned in § 170) the *poſition* of the *neutral Point*; it is proper to make uſe of an exceedingly ſmall electrometrical Ball [either of cork, or of pith of elder], ſuſpended by a thread of fine *flax*, ſubdivided to the greateſt poſſible degree; as mentioned at the End of the *Note* to § 10.

It is moreover proper, that this ſimple Electrometer ſhould be *inſulated*, upon a ſtick of ſealing Wax, as repreſented in Figure 9; leſt otherwiſe, it ſhould tend to convey ſilently away, from the *trebly-electrified* Body, any of its *natural* Share of Electricity; and thereby diſturb the Experiment, as explained in PART VII of this Treatiſe.

The *Thread* of the Electrometer ought *not* to be above *three-quarters of an inch* in length; becauſe, it can, then, in certain caſes, (in order to aſcertain the *neutral Point*,) be brought pretty near to the *trebly-electrified* Body, without there being any danger of the Ball of the Electrometer coming *into contact* with ſuch *trebly-electrified* Body, when that Ball comes to be *attracted* by it.

NOTE to SECTION 201, explained.

§ 591. The Propoſitions, ſtated in the NOTE to SECTION 201, relative to the *Center of Gravity* of certain Bodies, placed in given ſituations, muſt be underſtood to refer to thoſe Caſes only, in which the *Action of the force of Gravity* upon ſuch given Bodies, is ſenſibly *parallel*. That is to ſay, that thoſe Propoſitions will be true, *only* in the Caſe, when the *Diameter of the Baſe* of the Solid, if the Solid be *upright*, (or when the *Diameter of the Baſe* added to the *ſine of the Angle of Inclination*, if the Solid be *oblique*,) is, to the *Diſtance* between the Solid itſelf and the Center of Attraction of the Earth, *in a ratio infinitely ſmall*.

SECTION 308 referred to.

§ 592. Having mentioned, in SECTION 308, the comparative *ſharpneſs*, of the *main Stroke*, and of the *returning Stroke*; I will relate an Experiment, in which, that comparative *ſharpneſs* was ſtill more properly aſſertained; inaſmuch as two *equal* and *ſimilar* metallick Bodies were made uſe of, in that Experiment.

EXPERIMENT 63.

§ 593. I took two cylindrical tin Conductors (each of which was about three feet four inches long, by nearly four inches and an half diameter,) and I placed them *parallel* to each other, at the Diſtance of about *four inches and an half* aſunder. They were *both* well *inſulated*.

I *inſulated* a large Cylinder of Tin, which was about nine feet eight inches long, by above ten inches diameter; and I placed it at the Diſtance of about four feet from the two ſmall Tin Cylinders here-mentioned.

I then placed myſelf, upon an *inſulating* Stool, between the large Cylinder, and the two ſmall Cylinders; holding, the fore-finger of my right Hand, in very light contact with the *large* Tin Cylinder, which (for diſtinctneſs) I will call L; and holding, the fore-finger of my left Hand, in very light contact with *one* of the ſmall Tin Cylinders, which ſmall Cylinder I will call S.

§ 594. I then electrified ſtrongly the *other* ſmall Tin Cylinder, which (for diſtinctneſs) I will call the Prime Conductor. Upon doing which, I felt a ſwift ſucceſſion of *departing Sparks* at the End of the fore-finger of each of my Hands.

I then deſired another Perſon, ſtanding upon the Floor, to diſcharge the Prime-Conductor through his Body, which he did repeatedly; ſometimes, by ſuddenly approaching his knuckle, within the *ſtriking Diſtance* of the Prime-Conductor; and ſometimes, by ſuddenly approaching, within that *ſtriking Diſtance*, a large poliſhed Braſs Ball which he held in his Hand.—Each time, I felt the *returning Stroke* in both † my Hands and Wriſts, like the *ſudden* Diſcharge of a weakly electrified *Leyden Jar*.

§ 595. The other Perſon then placed himſelf upon the *inſulating* Stool, in the *ſame* poſition exactly, as I had juſt been in, with reſpect to the two Tin Cylinders S and

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† I always found, that the ſtrength of the *returning Stroke* was *greater* in my *left* Hand, which was in contact with the *ſmall* Tin Cylinder S; than it was, in my *right* Hand, which was in contact with the *large* Tin Cylinder L; provided the fore-finger of my *left* Hand was in full as *light contact* with the ſmall Cylinder S, as the fore-finger of my *right* Hand was, with the other Cylinder L. The reaſon of which evidently was; that, the *returning Stroke*, which took place in my *left* Hand, was produced by the *ſudden Return* of the *whole Quantity* of electrical Fluid that had been gradually expelled from the Cylinder S, both into my Body, and (through my Body) into the large Cylinder L; whereas, the *returning Stroke*, which took place in my *right* Hand, was produced by the *ſudden Return* of *that Portion* only of electrical Fluid, that had been gradually expelled from the Cylinder S (through my Body) into the other Cylinder L.

S and L. And I placed myſelf upon the Floor, in order to diſcharge the Prime-Conductor through my Body, in the *ſame* manner as the other Perſon had done.

This time, therefore, I received the *main Stroke*, which, in the firſt Part of this Experiment, the other Perſon had received; and the other Perſon received the *returning Stroke*, which I had received before.—And we both agreed, that there was no kind of compariſon, between the *ſtrength* of the *returning Stroke*, and *that* of the *main Stroke*; the *ſharpneſs* and *pungency* of the *returning Stroke* being ſo much ſuperior.

§ 596. It is perfectly evident, that the *returning Stroke* did proceed from the *ſudden Return* of that Quantity of electrical Fluid, that had [by the *ſuperinduced* elaſtick electrical Preſſure of the Prime-Conductor] been gradually expelled from the ſmall inſulated Tin Conductor S, which was (as we have already ſeen, § 593) of the *ſame ſize* and *ſhape* as the Prime Conductor. And it is extremely worth obſervation; that notwithſtanding the *much ſuperior ſtrength* of the *returning Stroke*, when compared to the *ſtrength* of the *main Stroke*; yet, the *Quantity of Electricity* which formed the *returning Stroke*, was *not near ſo great* as the Quantity of Electricity which formed the *main Stroke*. This Fact may be proved, at leaſt two ways, as follows.

§ 597. *Firſt*, it may be proved, *a priori*; inaſmuch as it muſt appear, from the Propoſitions contained in PART III; that, the *Quantity of Electricity*, expelled, from the ſmall Cylinder S, by the *ſuperinduced* elaſtick electrical Preſſure of the Prime-Conductor's electrical Atmoſphere, cannot be *as great*, as the Quantity of Electricity *contained* in the charged Prime-Conductor itſelf that produces ſuch *electrical Atmoſphere.*

EXPERIMENT 64.

§ 598. *Secondly*, the above-mentioned Fact is alſo to be proved, in the following manner.

Having arranged the whole Apparatus, as deſcribed in the latter Part of the *laſt Experiment*; (i. e. I being on the Floor, and the other Perſon ſtanding on the inſulated Stool;) I then charged the Prime-Conductor.

When the Prime-Conductor was fully charged; the other Perſon [who, whilſt the Prime-Conductor was charging, held his left Hand in contact with the Tin Cylinder S, and his right Hand in contact with the Cylinder L,] did remove his left Hand quite away from the Cylinder S; by which means, the electrical Fluid, which had gradually been expelled from that ſmall Cylinder S, could *not return* to it (as it would otherwiſe have done) when the *Prime-Conductor* came to be diſcharged.

§ 599. I then diſcharged the Prime-Conductor, with my knuckle: the Spark (tho' it produced no ſenſation of a *Leyden Jar's diſcharge,*) was *ſharp* and *ſtrong*. But, when I came to diſcharge, with my knuckle, the Tin Cylinder S, which was of the ſame ſhape and ſize as the Prime-Conductor; I found the Spark, from that Cylinder S, to be very *ſhort* and *inconſiderable*.

§ 600. So that, it appears; that, the *Quantity of electrical Fluid* which, in the Experiment 63rd, formed the *returning Stroke*, was very conſiderably *ſmaller* than the *Quantity of electrical Fluid* which formed the *main Stroke*: tho' the *pungency* of the *returning Stroke*, was ſo greatly *ſuperior*, in that Experiment, to the *pungency* of the *main Stroke* itſelf.

§ 601. We may, therefore, well venture to conclude, from theſe things; that, that *pungent* and *acute* electrical Senſation, which is commonly called the *Senſation of the Leyden Shock*, does not, near ſo much, depend, upon the *great Quantity of electrical Fluid* diſcharged; as it does, upon the vaſt *Suddenneſs*, and great *Velocity*, of ſuch electrical Diſcharge.

EXPERIMENT 65.

§ 602. I am the more ſtrongly confirmed in this opinion, by having, one Day, *diſcharged*, through my Body, (by means of very *indifferent* Conductors) *no leſs than twenty* † *ſquare feet* of *coated* (*Leyden*) *Surface*, highly charged; *without* feeling any ſuch kind of *pungent* or *acute* Senſation.

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† I ſhould *not* adviſe any Perſon, who is *not* very converſant with Electricity, to repeat this Experiment. The Body of a Man, forming a Part of the Communication, in this *Leyden Diſcharge*; infinite attention muſt be had, that, the reſt of the Communication, be formed, by means of Bodies that are very *indifferent Conductors* in their nature; for fear of receiving ſome violent *ſudden Shock*. This, is a very dangerous Experiment, if made with any kind of inattention; and it ought to be made, at firſt, with a *ſmaller* Quantity of Electricity, which may be *gradually* increaſed.

At the moment of the Diſcharge, the electrical Fluid ſeemed, entirely to *fill* my Cheſt; ſo as to make me perceive a *ſenſible Time* (however ſhort), during which, the electrical Fluid was flowing through it. I felt a great oppreſſion, on my Breaſt, which almoſt quite deprived me of breath, for a moment: yet, *no* kind of *ſharp Pain whatever* did reſult, from ſuch a *vaſt Quantity of electrical Fluid*, paſſing through my Body, as was thus diſcharged from thoſe *twenty ſquare Feet* of coated Surface.—But, I muſt not anticipate what belongs to another Subject.

SECTION 347. referred to.

§ 603. Having ſpoken, in SECTION 347, of the great *ſimilarity* which there is, between the electrical *returning Stroke*, and a *Leyden Shock*; I judge, that it will *not* be unacceptable to the Reader to be informed, that *Metal may be melted*, *by means of the returning Stroke*, without the aſſiſtance of any *coated* non-conducting Subſtance whatſoever.

EXPERIMENT 66.

§ 604. I took *three* tin Bodies, which (for diſtinctneſs) I will call A, B, and C; and I *inſulated* them all three, *ſeparately*, at ſmall Diſtances aſunder, in the moſt advantageous manner to obtain a *returning Stroke*, by means of theſe Bodies thus *inſulated*. I charged the

Body A *in plus*, as I ſhould have charged a common Prime-Conductor: upon doing which, the Body B, which was the neareſt to that Body A, became gradually *negative*, according to the Principles explained in the foregoing Treatiſe; and the third Body C, which was very near the Body B, became, of courſe, *poſitive*.

I then, (by means of a round poliſhed Braſs Body, that was properly connected with the Earth), did *ſuddenly diſcharge* the Body A, which was charged in the manner of a Prime-Conductor: but, I did *not* connect, either of the other *two* Bodies, with the *Earth*; *neither* did I connect together, any *two* of the *three* Bodies, A, B, and C. The inſtant, in which, I diſcharged the Body A, in the manner here-mentioned; a very ſharp electrical *returning Stroke* took place, in the interval between the Bodies C and B; and an exceeding fine *ſlip of Tinfoil*, which I had placed in that interval, *was melted*.

§ 605. The *inſulated* cylindrical Tin Body C, from which, iſſued the *electrical Fluid* that formed the *returning Stroke* in this Experiment, was only between *ten* and *eleven* Feet long; and the *Quantity of Surface*, which that *inſulated* Tin Body C had in contact with the Air, was *leſs* than *twenty ſeven* ſquare Feet.

The Bodies B and C were entirely out of the *ſtriking Diſtance* of the electrified Body A, during the whole time of the Experiment.

§ 606. Intending to purſue this ſubject farther, it appears to me unneceſſary, to give here a more particular detail, of the Experiments which I made with this Apparatus. But, I have ſaid thus much, in order to prove the great *ſtrength* and *ſharpneſs* of that kind of electrical Shock which I have called the *returning Stroke*; and in order to ſhew, that, the electrical *returning Stroke* is *not* produced, by the Diſcharge of (what is commonly called) a charged *Plate of Air*.

SECTION 391 referred to.

§ 607. I have explained in SECTION 391, the Manner, in which, a *prominent acute metallick Point* tends to become *out* of the *ſtriking Diſtance* of a charged Body, into whoſe electrical Atmoſphere it is immerged; namely, by diſcharging the *Electricity*, which is contained in *that Part* of the electrical Atmoſphere, into which ſuch *metallick Point* is *particularly* immerged.

This *Principle* is ſo evident, that, it is unneceſſary to explain it farther. It is, however, ſtrongly confirmed by the following Experiment.

EXPERIMENT 67.

§ 608. I placed, at the Diſtance of *twelve Inches*, from the Prime-Conductor mentioned above in § 582, a round Braſs Body, which had a very *fine hole* in that ſide of it which was next the Prime-Conductor. The Braſs Body was *ſtruck*.

§ 609. Having removed away the Braſs Body; I placed a very ſmall electrometrical Ball (which was ſuſpended by an exceeding fine *inſulated* thread of flax,) at the Diſtance of about twenty Inches from the Prime-Conductor; and I carefully obſerved, to what Degree of elevation the electrometrical Ball did arrive, when the Prime-Conductor was fully charged.

§ 610. I fixed a fine needle, into the ſmall hole of the round Braſs Body mentioned above (in § 608), and I puſhed it into that Body, till the *Point* of the needle projected, beyond that round Body, only *one twentieth* of an Inch. I then brought that round Body within the above-mentioned Diſtance of *twelve Inches* from the Prime-Conductor; and neither the Braſs Body, nor the Point, was ſtruck.

The whole Apparatus remaining as here deſcribed, I examined the ſituation of the electrometrical Ball mentioned in § 609; and I obſerved, that it had *not fallen*; at leaſt, *not* in any perceptible Degree.

§ 611. This Experiment tends, as far as it goes, ſtrongly to confirm my Principles, ſtated in PART XIII; inaſmuch as it evidently tends to prove, that, a *metal Point* may, *without diſcharging the electrified Body itſelf* producing the electrical Atmoſphere ſuperinduced, *preſerve* the Body, to which it is affixed, from being *ſtruck*; merely by diſcharging the Electricity contained in *that Part*, of the electrical Atmoſphere, into which it is *particularly* immerged.

SECTION 423 referred to.

§ 612. Having at the End of PART XIV, concluded *generally*; that, " an *high and acutely pointed Conductor*, " properly erected, muſt neceſſarily tend to *ſecure*, " that Part of the Building, to which it is affixed, againſt " any *direct main Stroke of Exploſion* whatſoever from a " Thunder Cloud;" it may not be ſuperfluous to obſerve, that, this Propoſition is full as true, with reſpect to *negative*, as it is, with reſpect to *poſitive* Electricity.

Electricans are, at preſent, I believe, very generally agreed; that, it *oftner* happens, in Thunder-Storms, that, the Matter of Lightning *aſcends* from the Earth to the Clouds, than that it *deſcends* from the Clouds to the Earth. Let us, therefore, conſider the caſe of the Clouds being *negatively* electrified.

Now, if a metallick Rod be properly erected; that is to ſay, if it have *all* the Requiſites particularly ſpecified in PART XIX of the foregoing Treatiſe; then, it will tend *gradually, peaceably and ſilently to reſtore the diſturbed electrical Equilibrium* between the Earth and the Cloud's *electrical Atmoſphere*, in as effectual a Manner, if the Cloud's Atmoſphere be *negative*, as if it be *poſitively* electrified. Becauſe, it is evident; if the Cloud's electrical Atmoſphere were *negative*; that, the metallick Conductor would then, at its lower End, *receive* Electricity, from the Earth, *with facility*, and would tranſmit ſuch Electricity, *with facility*, to the *negatively* electrified Atmoſphere *ſuperinduced* upon its *prominent* and *pointed* upper End; in a manner exactly ſimilar [†] to *that*, in which, ſuch *high and pointed Conductor* would *receive* Electricity, *with facility*, from a *poſitively* electrified Atmoſphere *ſuperinduced* upon its upper End; and would tranſmit ſuch Electricity, *with facility*, to the Common-Stock, with which, its *lower* Extremity is connected.

SECTION 425 referred to.

§ 613. In SECTION 425, I have aſſerted, as a Propoſition *univerſally* true, that, Bodies, charged with *different* kinds of Electricity, tend to *attract* each other, whenever their *oppoſitely electrified Atmoſpheres interfere.* It may, therefore, not be improper to take notice, in this place, of an intereſting Experiment, related by Dr. *Prieſtley*, in his Hiſtory [††] of Electricity, in the following Words.

[†] The Author would *not* have thought it neceſſary, to have thus enlarged upon a Propoſition, that muſt, from the Principles above-laid down, appear ſo extremely evident, as *that* which is here ſtated; had it *not* been for a Paper, written in *France*, ſome few years ago, recommending Conductors, of the conſtruction propoſed by Dr. *Franklin*, as the beſt, when the Clouds are *poſitive*; but, recommending Conductors, of a very different (and erroneous) conſtruction, to ſerve in the caſes, when the Clouds are *negatively* electrified. Whereas, it is manifeſt, that, ſuch Conductors for Lightning, as are recommended in the foregoing PART XIX, are, beyond compariſon, *the beſt of all*; whether the Clouds be *poſitively* or *negatively* electrified.

[††] See Dr. *Prieſtley's* Hiſtory of Electricity, Page 401.

712

"*Æpinus* has ſhewn, by a curious Experiment, that,
" if a metallick Conductor and a cork-Ball be both
" electrified *poſitively*, ſo as to *repel* one another; yet,
" if the Ball be forcibly brought within two, three, or
" four lines of the Conductor, it will be *attracted* by
" it; and it will be *repelled* again, if it be forcibly
" puſhed beyond that Limit of Attraction.—If the Ball
" be confined to move within the ſame ſmall Diſtance;
" a moderate Electrification of the Conductor will
" *repel* the Ball to its utmoſt Limit; but a ſtronger
" Electrification of the Conductor will cauſe the Ball to
" be *attracted*. He, therefore, limits the *general* Maxim,
" that, *Bodies poſſeſſing the ſame kind of Electricity repel*
" *one another; &c. &c.*"

§ 614. Theſe Experiments of *Æpinus* do *not* however, by any means, contradict that *general* Maxim, which he (here) too haſtily attempts to *limit*. For, it is evident, from the Principles I have laid down above; that, his electrometrical Ball, which was only *weakly* electrified *in plus*, did, by being immerged into the *denſe Part* of the *plus* electrical Atmoſphere of the *poſitively* electrified metallick Conductor, become, in fact, *negatively* electrified. Conſequently, the Ball was *attracted* towards the Conductor: becauſe, Bodies, charged with *contrary* Electricities, tend (as ſaid above § 23,) to *approach* each other, whenever the ſkirts of their [*oppoſitely* electrified] *Atmoſpheres* interfere.

SECTION 528 illuſtrated.

§ 615. I have explained above, in SECTION 528; that, the admirable Properties of a *metallick Point*, in Electricity, do *not* depend upon its *Form*, but upon its *projecting* beyond the Body or Bodies, to which it is (by a good communication) connected; and alſo, upon the ſmall *Quantity of Surface* which is has *in contact* with the Air. This Principle is clearly illuſtrated by the following Experiment.

EXPERIMENT 68.

§ 616. I took a piece of poliſhed, cylindrical, ſteel Wire, four feet long, and of about the thickneſs of a *fine horſe hair*; and I covered *each* End of it, with a piece of beeſwax, of about the ſize of a walnut. I then held this fine Wire by its upper End, letting the other End of it hang down; and having fully charged my large Prime-Conductor, I approached this Wire towards it; ſo that, the middle of the Wire ſhould be nearly at the height of that Prime-Conductor. The Prime-Conductor, tho' highly charged, was immediately *diſcharged in ſilence*; juſt as if I had approached a *prominent and acute metallick Point* towards ſuch Prime-Conductor.

§ 617. This is an evident demonſtration of what was ſtated above; namely, that, the property which a *metallick Point* has, of *diſcharging Electricity in ſilence*, does *not* depend, by any means, upon its *conical* or *pyramidical Form*; ſince, the fine poliſhed ſteel Wire, uſed in this Experiment, was a poliſhed *Cylinder*.—What *that* property *does* depend upon, I have ſhewn above in § 47.

SECTIONS 531 & *ſeq.* referred to.

§ 618. The *ſeventh* Requiſite to erecting Conductors [namely, that, the *upper Extremity* of a conducting Rod, muſt not only be *exceedingly acutely pointed*, and *very finely tapered*, but muſt alſo be *extremely prominent*] is likewiſe concluſively proved, by Dr. *Franklin*, in his ſecond and third Experiments, contained in his Paper, entitled, *Experiments, Obſervations, and Facts, tending to ſupport the opinion of the utility of* long pointed Rods, *for ſecuring Buildings from damage by Strokes of Lightning*.

The ſame Principles are moreover confirmed, by the ſeventh and eight Experiments, of Mr. *Nairne* † F. R. S, contained in his excellent Paper, entitled, *Experiments on Electricity, being an attempt to ſhew the Advantage of elevated pointed Conductors*.

SECTION 543 referred to.

§ 619. Having ſaid, in SECTION 543, that, " ſuch " Conductors, as are *not* intended for *Experiments*, but

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† See Philoſophical Tranſactions, Volume 68, Part 2, Page 829 & *ſeq.*
1099.

" ſolely for *ſecuring* Buildings againſt damage by Light-
" -ning, do *not require* to be ſupported upon *Glaſs* or
" any other *non-conductor*" ; it may not be quite foreign to the ſubject, to add a few words, with reſpect to ſuch metallick Conductors as are intended for *Experiments*; as far, at leaſt, as may relate to the *ſecurity of the Edifice* itſelf, upon which ſuch Conductors are erected.

§ 620. It is, in the firſt place, for reaſons aſſigned above (§ 521), a thing of great conſequence; that, any *interruption*, intentionally left in a conducting Rod for the purpoſe of applying electrometrical Balls, electrical Bells, &c, ſhould be but *very ſmall*. I think it is never ſafe, that, ſuch *interval* ſhould exceed *half an inch* at moſt; as every additional length of *interruption*, in an interrupted metallick Conductor, which is even *perfect* in every *other* reſpect, will render *ſuch Conductor* (and alſo the *Building* upon which it is erected,) *more liable to be ſtruck by Lightning*. And if ſuch an interrupted Conductor *be ſtruck by Lightning*; the greater the metallick *interruption* is, the more powerful will be alſo the *lateral Exploſion*.

§ 621. If electrical *Bells* be applied; the hammer, that vibrates between them, ought *not* to be above *one eighth of an inch* thick; in order, *firſt*, not to add unneceſſary weight; and in order, *ſecondly*, not to fill up too much of the *(half inch) interval*, between the two Portions of the Rod. The hammer ought, however, to be made pretty *broad*; in order, that it may be able to contain a proper degree of Electricity. The ſafeſt and beſt way of *ſuſpending* the hammer, is, by means of an inſulated, long, ſtrong metal *hinge*, made extremely free: which hinge will prevent the *hammer* from ever being thrown out of its place, as it was, in the inſtance related above in § 442.

§ 622. When it is required to aſcertain the *Quality* of the Electricity, of any Cloud's electrical Atmoſphere *ſuperinduced*; I think, that the beſt way, is, to make uſe of a *Leyden Apparatus*: but, ſuch Apparatus ſhould be capable of diſcharging itſelf *ſpontaneouſly*, before it becomes highly charged.

§ 623. I am moreover of opinion, that, in ſuch a Conductor, as has an *interruption* intentionally left in it, for the purpoſe of making Experiments; there ought always to be a *piece of metal*, adjuſted (by means of a ſtrong metal hinge,) to one of the Portions of the Rod; which *piece of metal* ſhould be furniſhed with a long *inſulating* handle, in order for the Obſerver to have it in his power, to render the metallick *communication* perfect, or almoſt perfect, ſhould the *ſuperinduced Electricity* grow, at any time, dangerous, and exceſſive.

§ 624. Now, the manner, in which, the upper End of a Conductor, erected from the purpoſe of making Experiments, ought to be *inſulated*, is, by no means, an indifferent circumſtance. I ſhould never adviſe, for example, the ſupporting conducting Rods, in any caſe, by means either of *Pillars*, or of *Tubes*, of *Glaſs*; as I conſider *both* theſe Methods to be often dangerous.

§ 625. In SECTION 546, I mentioned one objection to *Pillars of Glaſs*; but, the chief reaſon for my objecting to *Pillars of Glaſs* (however *thick* they might be made, in order to reſiſt the power of Winds, &c.) is; that, if ſuch *interrupted* Conductor [ſee § 620] ſhould ever chance to receive a *violent Stroke* of Lightning; the *Glaſs Pillar*, ſupporting the Rod, would probably be *broken*, by the violence of the Shock; and the *metallick Conductor* would, conſequently, be thrown down.

§ 626. The other Method of making conducting Rods paſs through *Tubes of Glaſs*, may alſo be attended with bad conſequences, as, I think, muſt appear, from Dr. *Franklin's* † Experiment, with the ſlip of *Gold leaf* placed between two pieces of *thick looking-Glaſs* cloſely confined, which pieces of *Glaſs* were quite *ſhivered*, by an *electrical Shock* diſcharged through the Gold leaf; and as muſt alſo appear, from Dr. *Prieſtley's* †† Experiments on the *lateral Force* of electrical Exploſions, which *lateral Force* exerts itſelf, even when wires are neither *melted*, nor ſo much as very conſiderably *heated*.

If the metallick conducting Rod have any play in the *Glaſs Tube*; then, any ſtrong motion given to the metallick Rod, (by the Wind, or by any other Cauſe,) will probably cauſe a *Tube*, made of ſuch a brittle material as *Glaſs*, to be cracked, or to be perhaps ſhivered to pieces.

If, on the contrary, the metallick Conductor be introduced *tight* into the *Glaſs Tube*; then, the danger will be conſiderably increaſed. And Mr. *Cavallo*, ††† ſpeaking of Dr. *Franklin's* Experiment here mentioned, very properly obſerves; that, "if the Glaſſes, incloſing "the metal, be preſſed by heavy weights; then, a *re-"markable ſmall* (electrical) *Shock*, is capable often, not "only to raiſe the weight, but to *break ſuch thick Glaſſes*, "that otherwiſe require the force of a large Battery."

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† See Dr. *Franklin's* Philoſophical Works, Page 69.
514

†† See Dr. *Prieſtley's* Hiſtory of Electricity, Page 681 *& ſeq.*
712

††† See Mr. *Cavallo's* Treatiſe of Electricity, Page 62.
404

§ 627. The moſt perfect way, by much, of erecting ſuch Conductors, as are intended for making *Experiments* upon the Electricity of the Clouds, (by means of electrical Bells, electrometrical Balls, &c), is, *to ſurround* all the Parts of the Rod which lay near the Building [or near the Maſt] upon which the Rod is erected, *with a very thick coat*, or *beeſwax*, of *beeſwax* mixed with *roſin*, or of ſome *ſimilar* kind of *non-conducting* ſubſtance. The *upper Part* of this thick *non conducting* coating, ought to be very carefully ſecured againſt *Rain*, &c. by means of a large *conical Cap* of metal, made in the common way.

§ 628. Leſt any one ſhould imagine; either that, this *non-conducting coating* might render the Rod more liable to be melted by Lightning, than it would have been, if ſuch *coating* had *not* been there; or that, the *lateral Force*, of an electrical Exploſion which was *not* ſufficient abſolutely to *melt* the metallick Rod, might ſtill, notwithſtanding, cauſe ſuch *non-conducting coating* to fly to pieces, as if it were of *Glaſs*; I ſhall relate a few Experiments, which I made, to aſcertain what Effect would really be produced by ſuch *coating*.

EXPERIMENT 69.

§ 629. I took a very fine ſteel Wire, *three quarters* of an inch long, and I covered the middle of it with a very thick Coat of *beeſwax*, about *one quarter* of an inch long; leaving, on each ſide, about *one quarter* of an inch of metal *uncovered*.

I then diſcharged, between three and four ſquare feet of *Leyden ſurface*, through this fine Wire, and the *whole Wire* (as well the *coated*, as the *uncoated*, Part,) was melted and diſperſed; juſt in the ſame manner, as a ſimilar piece, of the ſame Wire, [*when uncoated*,] was, upon my diſcharging through it *the ſame Quantity* of Leyden Surface.

EXPERIMENT 70.

§ 630. I then took a fine ſteel Wire, of the ſame length as that mentioned in the beginning of the *laſt* SECTION, but of a ſize *larger* than it; and I coated it, exactly in the *ſame* manner, as I had done the other.

I then diſcharged, through this Wire, the *ſame Quantity* of Leyden ſurface, as I had, through the former one. The conſequence of this was, that, the *uncoated* Part of this Wire, was *melted*, and *diſſipated into ſmoke*; yet, upon opening the *Beeſwax* carefully, I found the Metal *unmelted*: ſo that, this *non-conducting coat* had preſerved it.

§ 631. Leſt it ſhould be imagined; that, the Reaſon of *this* was, becauſe an *electrical Shock* acts (as, in fact, it is well known to do,) *more ſtrongly* upon the *two Ends* of a Body through which it is diſcharged, than it does upon the *middle* of ſuch Body; I will relate another Experiment of mine, which is deciſive, and which will evidently ſhew, that *this* is *not* the true Cauſe, of the Effect related in the *laſt Experiment*.

EXPERIMENT 71.

§ 632. The fine ſteel Wire, that I made uſe of in this Experiment, was of the *ſame Length* as that made uſe of in my Experiment 70 (i. e. *three quarters* of an inch long); and it was alſo of the *ſame thickneſs*.

At the Diſtance of about *one twelfth of an inch* from *each End* of this fine Wire, I covered the Metal all round, for the ſpace of about *one ſixth of an inch*, with a very thick Coat of *beeſwax*; leaving the *middle* of this piece of fine Wire, [for the ſpace of about one quarter of an inch,] *uncoated*.

§ 633. I then diſcharged the *ſame Quantity* of Leyden ſurface, through this Wire, as I had done, through the other Wire, in my Experiment 70. The conſequence thereby produced was; that, the *uncoated* Portion (of *one twelfth* of an inch long) at *each End* of the wire, and the *uncoated* Portion [of *one quarter* of an inch long] in the *middle* of the Wire was *melted*, and *diſſipated into ſmoke*; but, that, the two Portions (of *one ſixth* of an inch each) of the Wire, which were between the middle of it and the two Ends, and which were *coated with beeſwax*, were *not* melted, So that, the *Metal* was, alſo, in this inſtance, preſerved, by means of the *non-conducting coating* by which it was ſurrounded.

§ 634. Theſe are Experiments, which require care: for, if the Charge be too *weak*, *no Part* of the Wire will be melted; if, on the contrary, the Charge be too *ſtrong*, every Part of the Wire, whether *coated* or *uncoated*, will be deſtroyed, as it was in my Experiment 69.

In all the caſes, in which, the *uncoated* Part of the *ſteel* Wire is deſtroyed; and the *coated* Part, is not;

there is to be ſound, round the *ſteel* Wire, within the *non-conducting* coating, a kind of *black duſt*.

The above-mentioned Experiments ſucceed much the beſt, when a very fine *ſlip of Tinfoil* (inſulated of a piece of *ſteel Wire*) is made uſe of. Particular care is neceſſary, *not* to injure the *Metal*, in taking off the *coating*.

N. B. The *ſoft* kind of red *ſealing Wax* makes a very good kind of *non-conducting* coating, for theſe Experiments.

§ 635. It is evident, from theſe Experiments, that, if a *metallick conducting Rod*, be made *ſufficiently thick* to conduct the Lightning with ſafety to itſelf, as preſcribed above (§ 522); that, the addition of the *non conducting* coating, will only tend to give *additional ſecurity* to ſuch Rod itſelf.

§ 636. The Way, in which, I explain this Effect, is ſimply as follows.

Beeſwax, Sealing Wax, and Roſin, are, when *cold*, *non-conductors* of the electrical Fluid; but, they acquire, when *heated*, the power of *conducting* Electricity; as is perfectly well known.

Now, it is evident; *before* a piece of Metal can be *melted* by means of any Charge of Electricity paſſing through it; that, ſuch piece of Metal muſt become extremely *hot*. The *Beeſwax*, which is in contact with ſuch *hot Metal*, will, therefore, be alſo rendered *hot*; and will, conſequently, be thereby made to acquire the power of *conducting* Electricity. So that, in fact, the *non-conducting coating* does, during a ſhort ſpace of time, *increaſe the capacity of the Conductor*.

ERRATA neceſſary to be corrected.

PAGE	LINE	FOR	READ
22	1	s	is
31	1	wollen	woollen
32	20	H	M
ditto	ditto	Ball	Balls
52	laſt	$p \times aa$	$p \times cc$
58	12	119	81
70	23	*three quarters*	*five quarters.*
78	laſt	This	This is
83	15	iſhued	iſſued
86	laſt	Poin	Point
131	6	*ſimilarly*	*ſimilarily*
135	9	§ 72	§ 72 and § 182
139	25	§ 375	§ 357
ditto	laſt	§ 360	§ 361
140	11	of Earth	of the Earth
142	laſt but one	§ 361	§ 358
ditto	ditto	§ 363	§ 361
147	3	into	in
163	14	ſpoke	ſpoken
170	10	where	were
178	8	Clou d	Clouds
182	6	*half*	*one eighth of*
ditto	7	*half*	*an eighth of an*
212	1 and 2	*thei pacmon-table*	*the incomparable*
213	3	ſufficient	ſufficiently
232	20	*Man*	*Mankind*

Pl. 1.

Fig. 5.

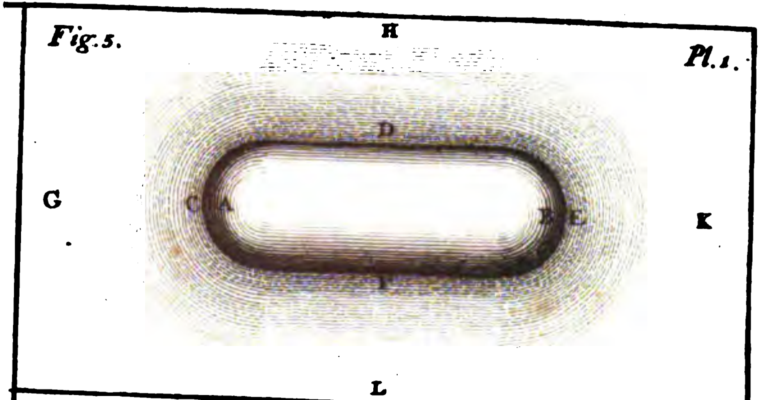


Fig. 6.

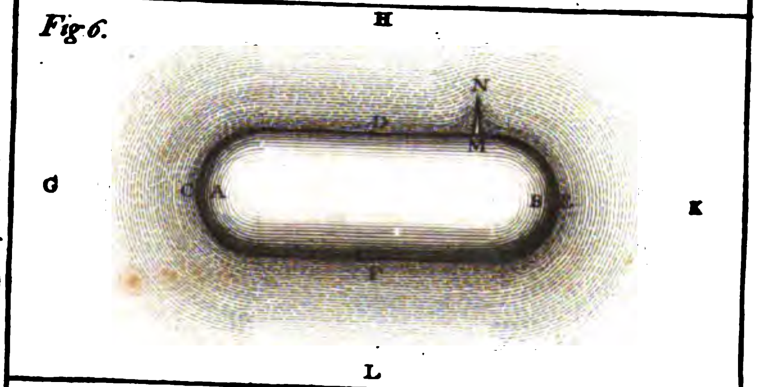


Fig. 7.

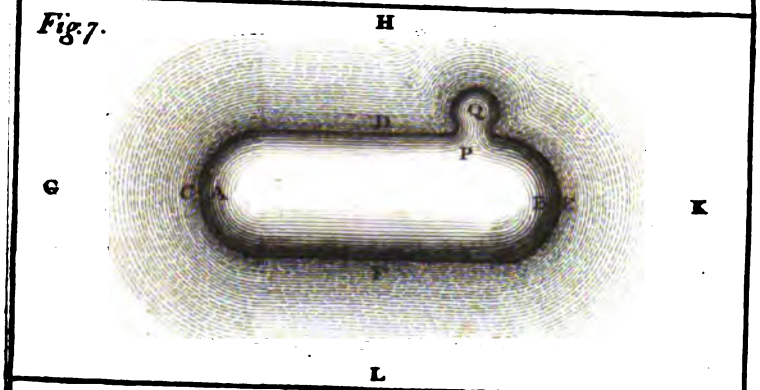
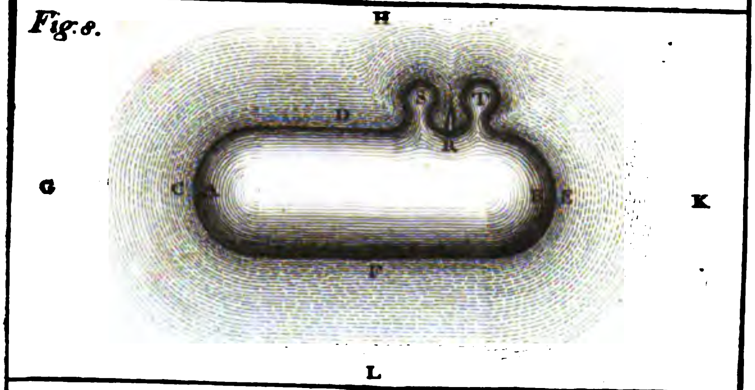


Fig. 8.



Pl. 2.

Fig. 9.

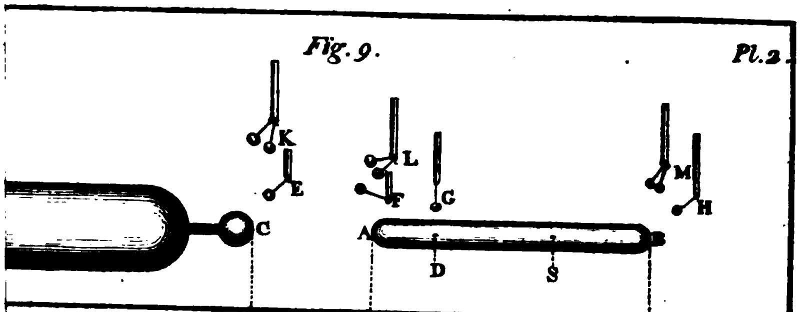


Fig. 10.

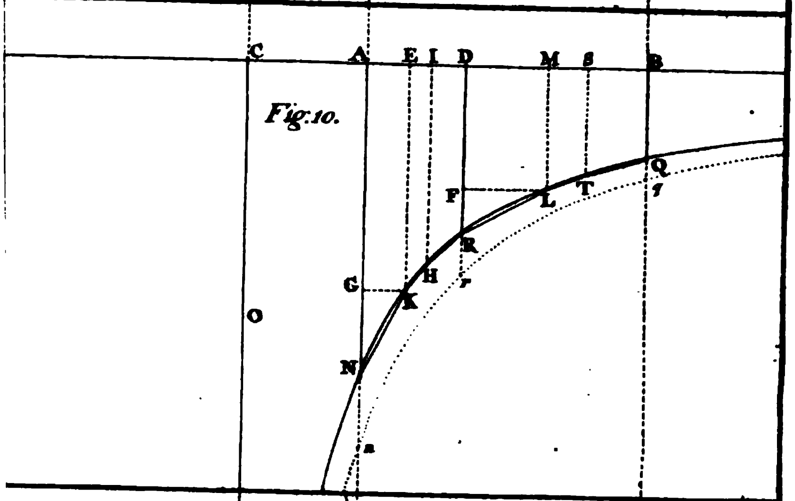
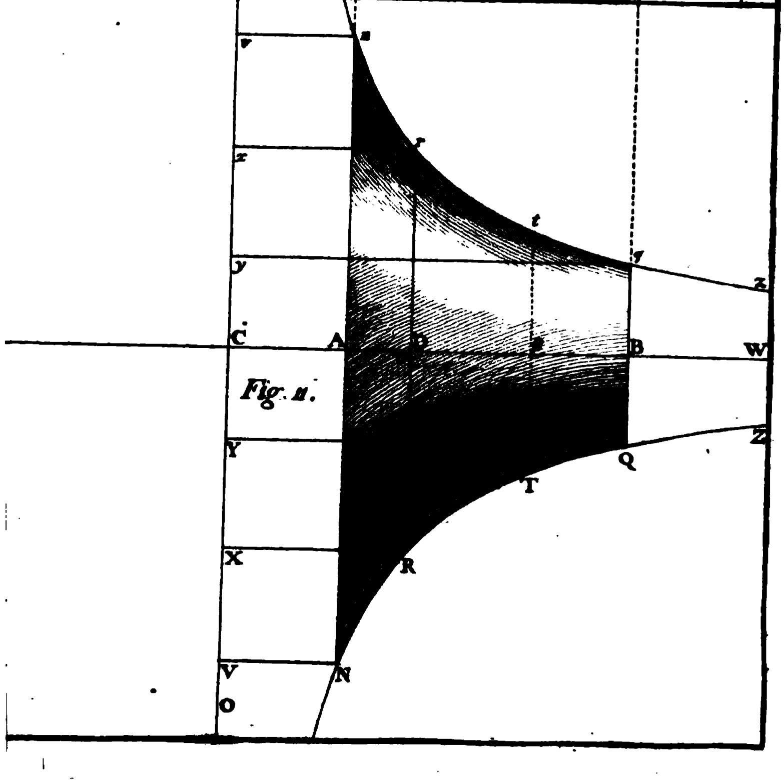


Fig. 11.



Pl. 3.

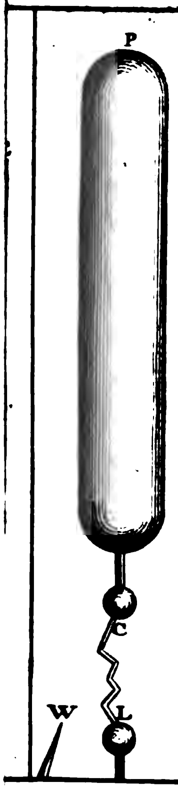


Fig. 13.

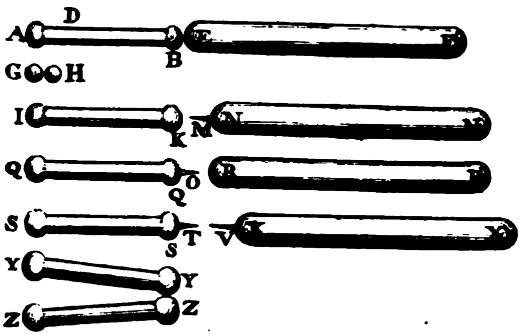
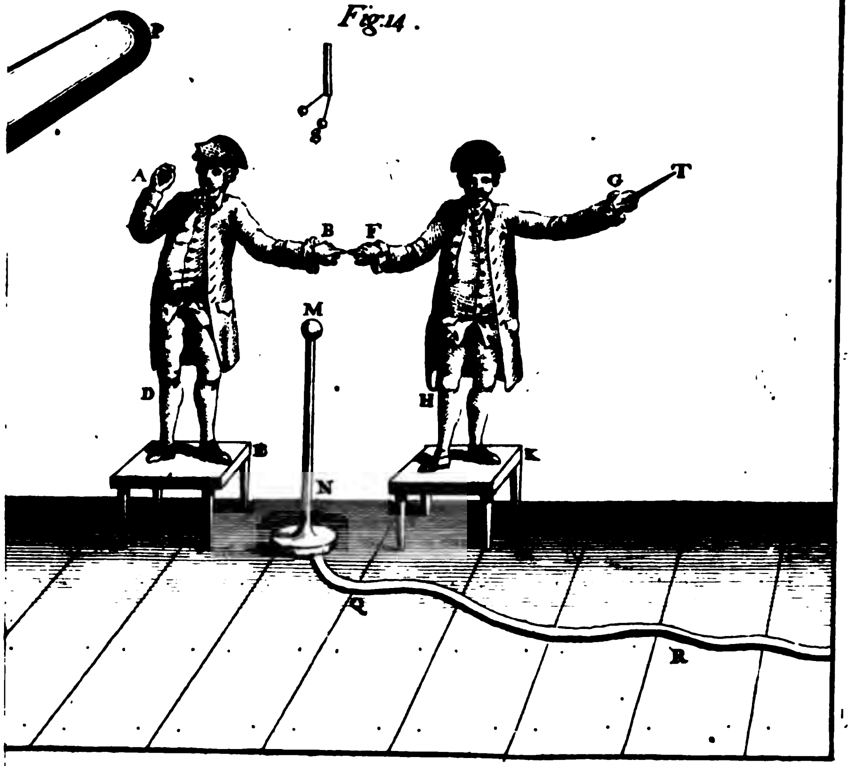


Fig. 14.



Pl.

Fig. 15.

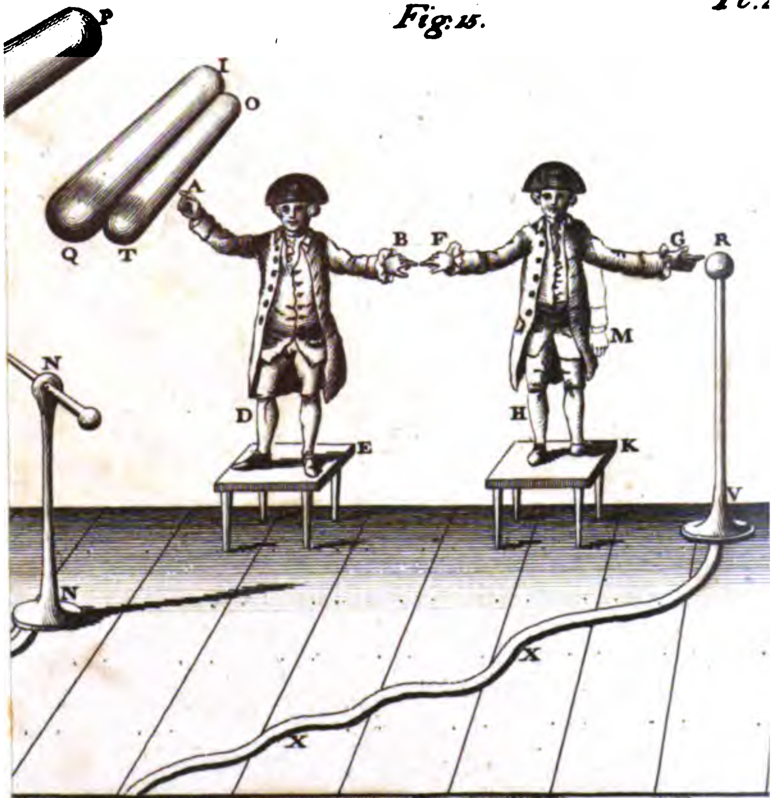
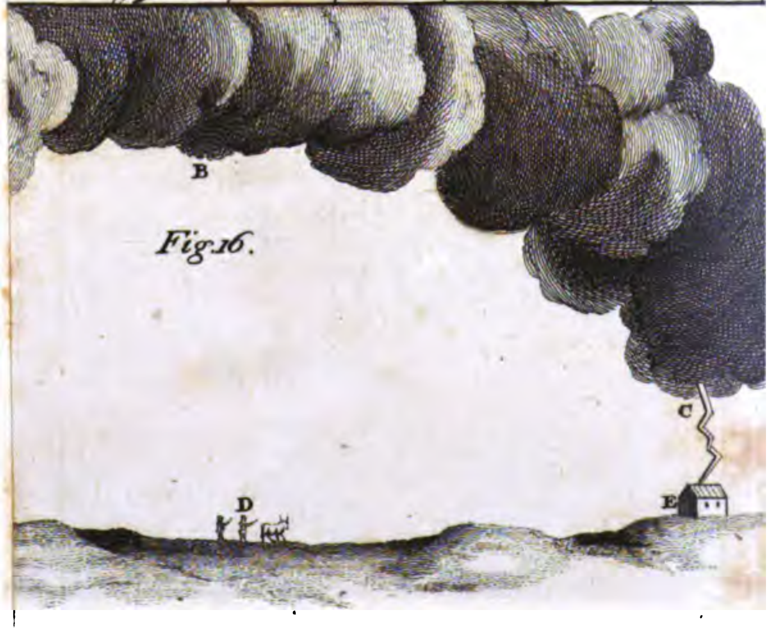


Fig. 16.



Pl.

Fig. 17.

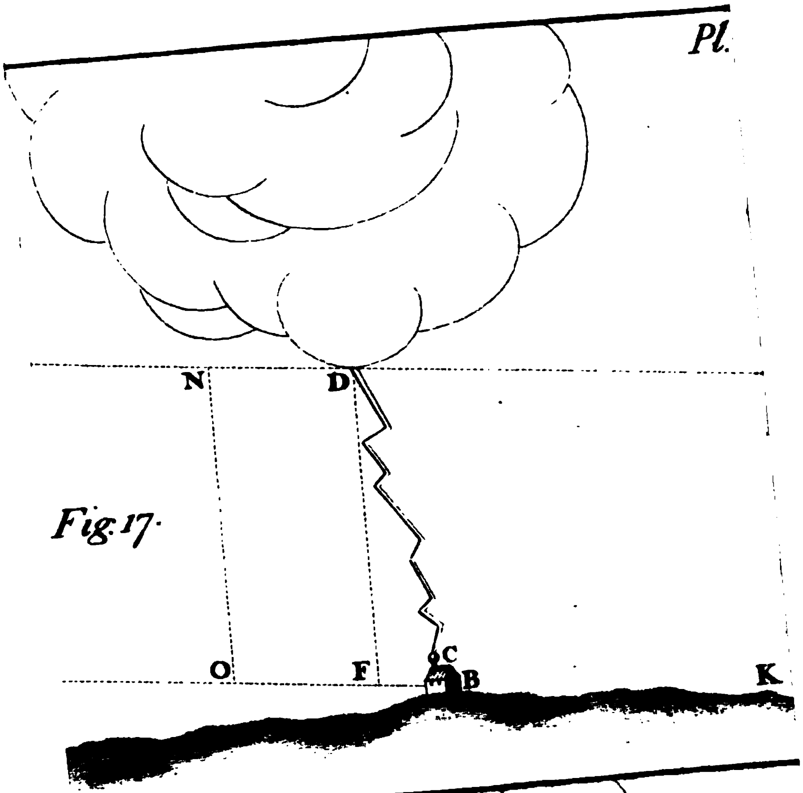
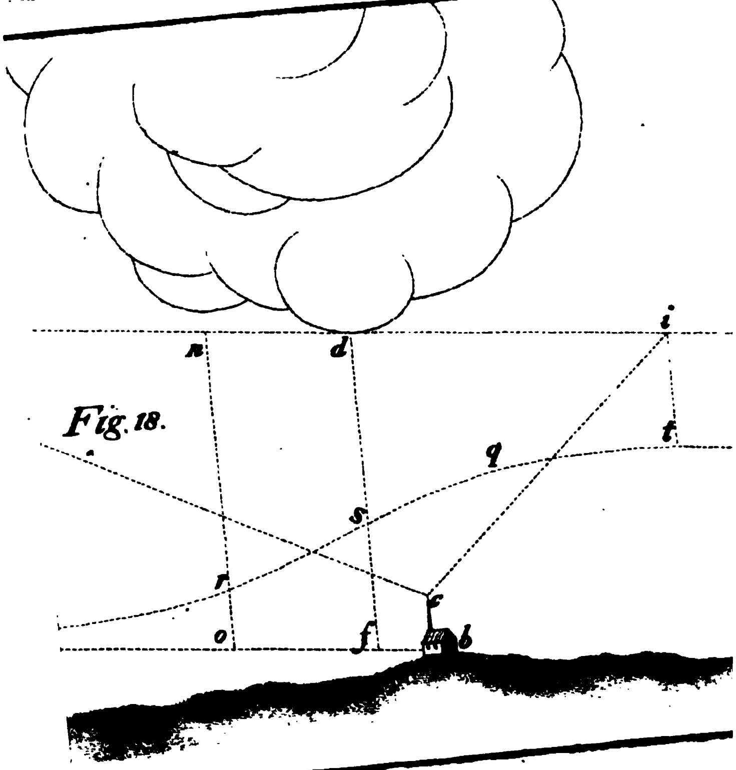
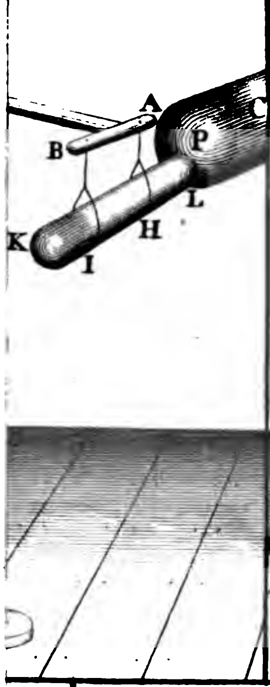


Fig. 18.

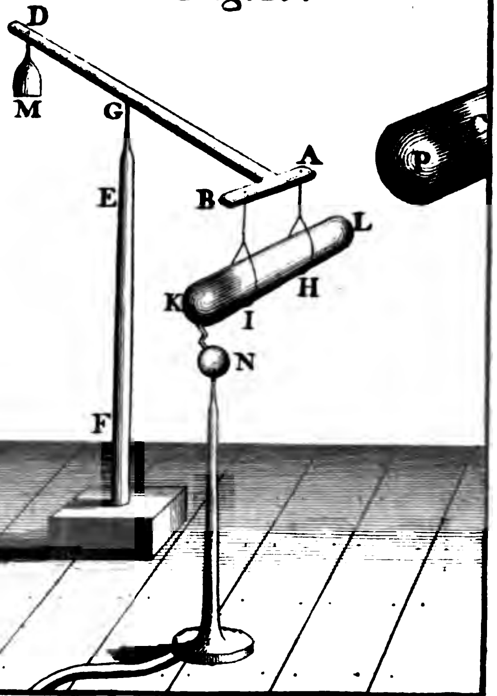


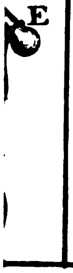
Pl. 6.



9.

Fig. 20.





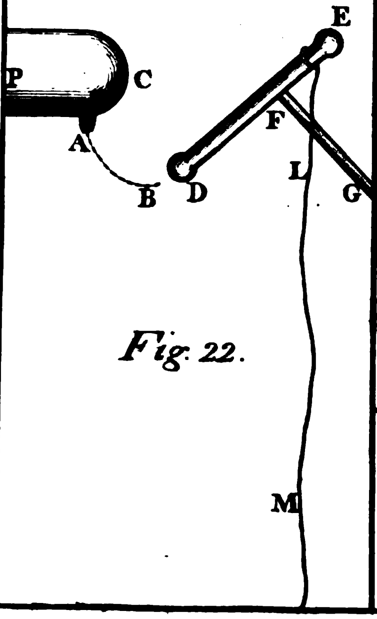


Fig. 22.

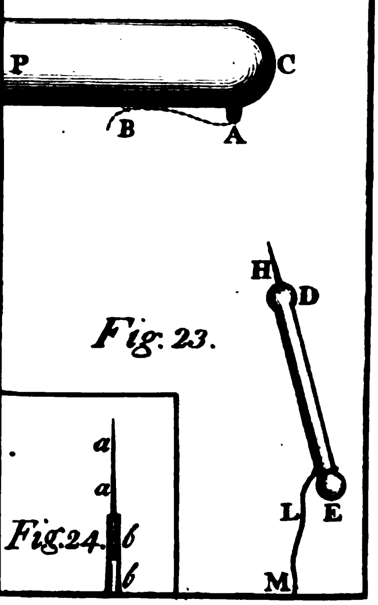


Fig. 23.

Fig. 24.